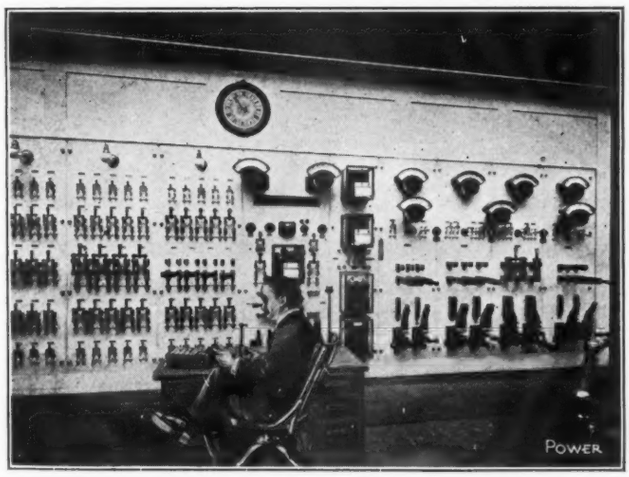
POWER

Vol. 36 NEW YORK, JULY 16, 1912 No. 3

The Electrician and the Engineer

The electrician has it all over the engineer. He is given a handsome marble switchboard with ammeters and voltmeters and wattmeters and all sorts of instruments, fixed and



portable, for measuring the current which he handles. The engineer is given a steam gage and a water column. The electrician, with all of the instruments, cannot make any more current than the engineer gives him, nor make it go any farther.

The engineer, who is responsible for the input and output of the plant, often has not so much as a pair of scales to tell if he is getting as much coal as he is paying for; no calorimeter to test the quality of the coal; no water meter to show how much water he is evaporating; no pyrometer to test the temperature of his furnace or of the escaping gases; no draft gage; rarely, unless the maker of the heater gives it to him, a thermometer to tell how hot the feed water is; no Orsat or other apparatus to tell how complete the combustion of the fuel has been and how much unnecessary air he is heating up to be sent out of the chimney; no indicator to tell how the valves of his engine are set or how much power the engine is developing; no engineer's level to tell if the engine and shafting are in line. If he asks for these things he is likely to be told that he is getting fussy, scientific and unpractical and to be sent back discredited to his steam gage and water column.

An engineer can hardly be expected to do the best that can be done when he has no means of knowing what he is doing; to proceed intelligently to better conditions when he has no means of determining what the existing conditions are.

It is no justification for an employer to say that his engineer would not know what to do with such instruments and apparatus if he had them. Try him and more than likely you will find that he does know these instruments and how to make good use of them, and that he can save you many times their cost by using them. If he cannot or will not, there are those who can and will.

New San Joaquin Power Plant

By Howard H. Bliss

A 16,000-kw. hydroelectric plant operating under a static head of 1405 ft.

Three-phase current is generated at 2300 volts and a large part of it is taken by motors.

To supply the rapidly increasing demand for current in the great central valley of California, the San Joaquin Light & Power Corporation has recently installed a new hydraulic plant and made extensive improvements in its reservoir and ditch system. The new plant replaces the first generating station of the company, installed in 1896, which was once famous for using the highest head of water in existence. Modern practice and high efficiency are well exemplified in the new installation.

The power house is on the main San Joaquin River, about 30 miles from Fresno. It is of steel with double walls of cement plaster and reinforced-concrete floors and roof. The floor dimensions are 148 ft. by 71 ft. 9 in. Current is generated by four 4000-kv.-a. generators, three-phase, 60-cycle, 2300 volts. These are driven by Doble impulse wheels, one to each unit, running at 400 r.p.m. Water under a static head of 1405 ft. is delivered to the wheels through fixed needle nozzles, having auxiliary nozzles which waste the water into the tailrace when the governors close the needles at higher than a predetermined speed. The relief device has a slow-closing mechanism which shuts off the waste water at a safe rate. Each pair of units is supplied from one pipe line, 34 in. in diameter at the bottom, ¾ in. thick, lap welded; and 44 in. at the top, ¼ in. thick, lap-riveted. The horizontal length of the penstock is 3900 ft.

At the head of the pipe line is a forebay regulating reservoir eight acres in area, to which the water is brought through a seven-mile conduit. Concrete-lined tunnels make up two miles of this, a steel flume 966 ft., a concrete flume 715 ft., and the rest is an earth ditch in disintegrated granite. Owing to the serious annoyance from gophers and ground squirrels which had caused many breaks in the ditch while the old power house was in commission, a concrete core-wall was built into the downstream bank when the ditch was enlarged to the present dimensions. The foundation of the core-wall was placed 2 ft. or more below the bottom of the ditch, and the wall carried up 6 in. thick to a point 1 ft. above the flow line for 100 sec.-ft. Two small ponds near the intake have been utilized as sand traps.

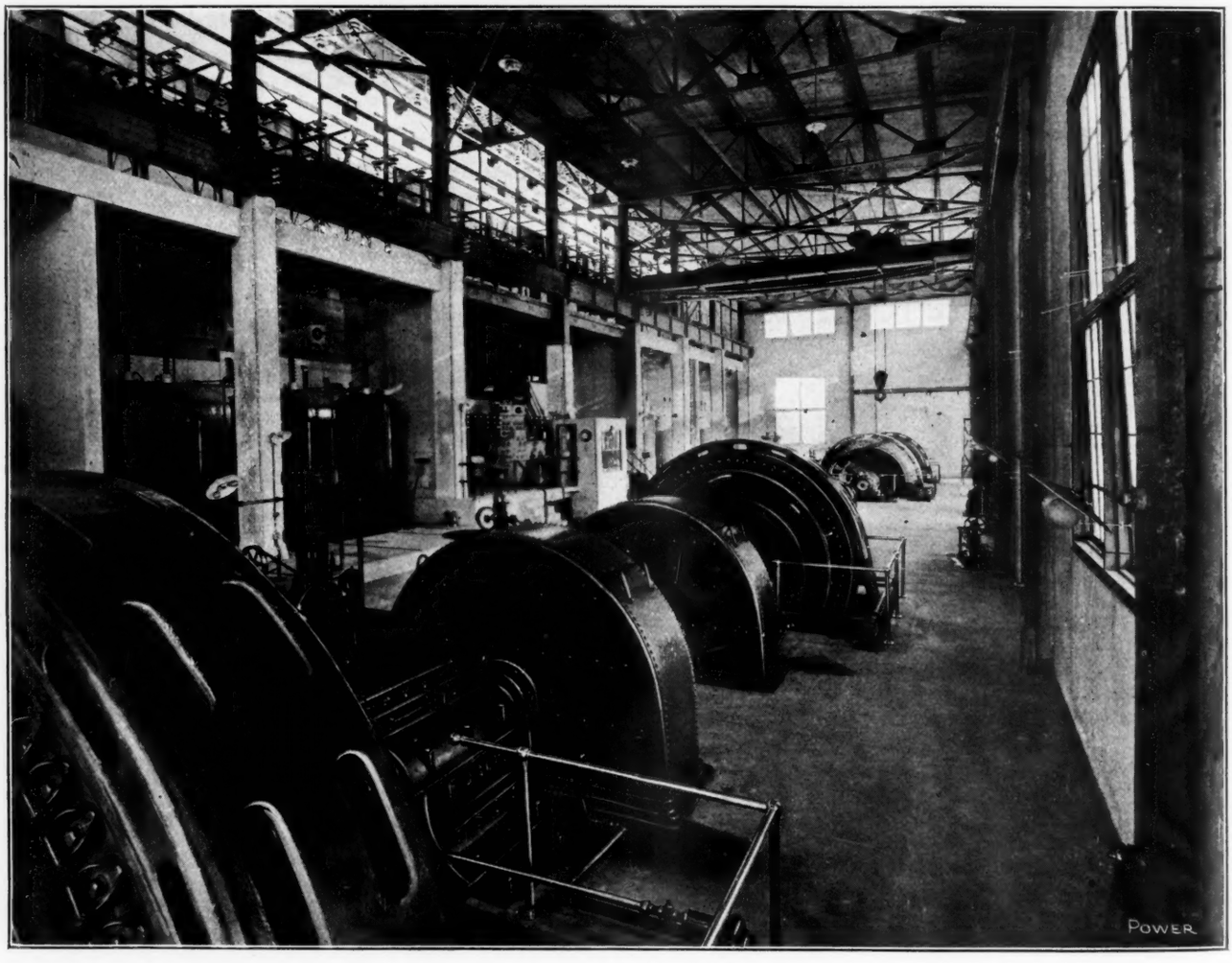


FIG. 1. INTERIOR OF SAN JOAQUIN POWER HOUSE

At the head of the ditch is a small diverting dam, placed at the junction of the two northern branches of the San Joaquin River. Several miles up the northern or larger fork is a reservoir capable of storing 51,000 acre-feet. The

Crane Valley which it occupies has been used for water storage since the company began operations, and the old dam is inclosed within the new and higher one necessitated by the new installation. The new dam is 2000 ft. long and 150 ft. high, with a concrete core-wall reinforced with square steel bars. On the upstream side of the dam an earth-fill of disintegrated granite and red adobe clay was deposited by hydraulic means and riprapped 2 ft. thick. On the downstream side rock fill is used for about half the length of the dam in the deepest part of the cañon and earth-fill for the remainder. A concrete tower in the reservoir near the dam is used for controlling the outlet water, which is sent through a tunnel beneath the dam. At the end of the tunnel the water can be sent down the river channel several miles to the forking, where the diverting dam starts it toward the new power house, or it can be turned into the ditch line leading to the company's power station No. 3, four miles away.

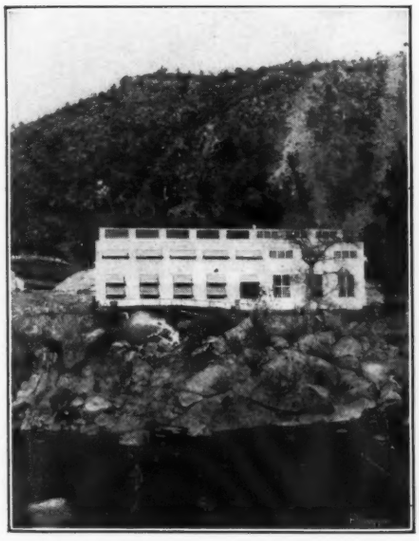


FIG. 2. EXTERIOR VIEW OF STATION

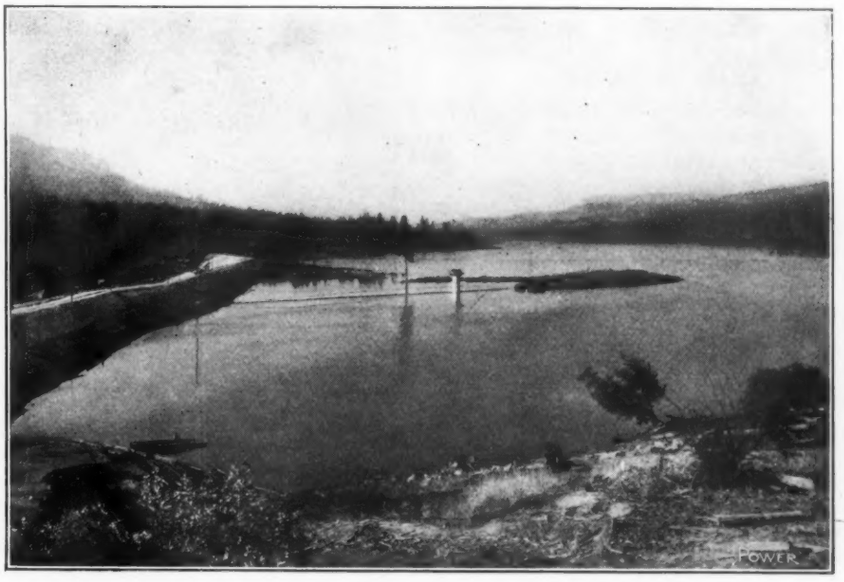


FIG. 3. DAM 2000 FT. LONG IMPOUNDING 51,000 ACRE-FEET

This plant contains two 1000-kw. units driven by impulse wheels working under 400-ft. head. The tailrace empties into the channel of the north fork and the water used in No. 3 station is used again in the new power house. At present, No. 3 plant is not operated but is held as reserve. An additional fall of 350 ft. between this place and the diverting dam can be utilized later if necessary by constructing another station.

In the new power house are four banks of 1500-kw. water-cooled transformers to step up the voltage from 2300 to 60,000. At present the voltage is raised only to 30,000 at this plant. Two lines carry the power 18 miles to the Coppermine switching station in the San Joaquin Valley, where a part of it is stepped up to 60,000 for transmission 195 miles to Bakersfield. From the Coppermine station two 30,000-volt lines run to Fresno, 17 miles, and one to Madera, 28 miles. The latter is continued 35 miles beyond to Merced, and 22 miles beyond that to Merced Falls. There the voltage is reduced to 10,000 for transmission to a mining district in Mariposa County. The company's service reaches seven counties: Mariposa, Merced, Madera, Fresno, Tulare, Kings and Kern. There are 676 miles of transmission line and 563 miles of distributing line.

A large part of the power is taken by motors running irrigating pumps, oil-well and mining machinery, street cars and machine shops. Hence the load factor is exceptionally favorable, though the power factor is generally low. Table 1 shows the operating data for 11 months in 1911, where the load factor is computed by dividing the kilowatt-hours for the month by the product of the number of hours in the month by the monthly peak.

TABLE 1. OPERATING DATA OBTAINED IN 1911.

Month	Kw.-Hr.	Monthly Peak	Load Factor, Per Cent.
January	3,100,000	6,300	66.1
February	2,910,000	6,350	68.2
March	3,360,000	6,500	69.4
April	3,050,000	7,400	56.8
May	3,690,000	7,950	62.4
June	3,830,000	7,650	69.5
July	4,200,000	7,050	80.0
August	4,290,000	8,850	65.1
September	4,090,000	9,250	61.4
October	4,560,000	10,000	61.3
November	4,260,000	10,000	59.2

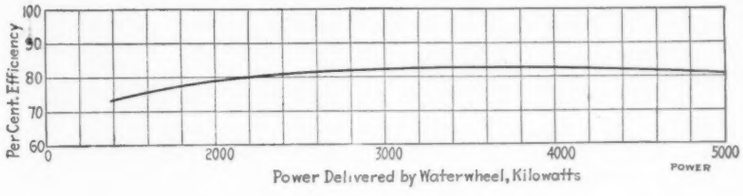


FIG. 4. EFFICIENCY LOAD CURVE

At Bakersfield the company has just finished installing a steam-auxiliary plant of 7000 kw. capacity. It contains one General Electric turbine and generator of 2000 kw., and an Allis-Chalmers turbine of 5000 kw. It is intended to run these units as rotary condensers when not needed for power, to correct the very low power factor.

Before the final acceptance of the waterwheels for the main plant, a thorough efficiency test upon the installation was made by the J. G. White Co., which had charge of the design and construction work for the power corporation. Two units were tested, No. 2, which had been in operation a year, and No. 4, which had just been set up. The former showed higher efficiency than the latter, due to the smoothing of the bearings by wear, and both machines considerably surpassed the contract guarantees, although the friction and windage of the generators were charged against the waterwheels.

A rather unusual method of loading was resorted to and found eminently successful. The current from the generators was stepped up to 30,000 volts in the transformers and run to a raft anchored in the tailrace. The three wires were connected to three 1½-in. pipes which projected down vertically into the water. They were 5 ft. apart and at the apices of an equilateral triangle. A previous trial had shown how deep the pipes should

go for each load desired. It was found that the current was perfectly divided between the three phases and absolutely constant during the 20-min. test runs. The reason for adopting the scheme was that the commercial load was too variable and at low power factor.

The input to the wheels was measured by gaging the pressure head behind the nozzles, adding the velocity head, and multiplying by the quantity of water as measured by a venturi meter in the pipe line. The output was taken as the mean of the readings of three wattmeters on the low-tension current, plus the armature loss, core loss and load losses, which last, in accordance with the recommendations of the American Institute of Electrical Engineers, were taken equal to one-third of the short-circuit core loss. The generator losses were calculated from the results of tests upon them by the J. G. White Co., at Schenectady, before acceptance.

Following is a tabulation of the results for the wheels tested:

Load		Guar.	Realized Efficiency	
Hp.	Kw.	Eff.	Unit No. 4	Unit No. 2
3,050	2,275	80%	80.0	80.6
4,575	3,413	81%	82.2	83.2
6,100	4,551	81%	82.2	82.4

Finally a building-up test of the efficiency from three-fourths load to 27 per cent. overload was run, resulting in the efficiency curve shown. This was on the newer, less efficient wheel, and as in the previous tests the windage and friction of the generator were neglected.

An Old Mine Pump

Modern mine pumps are constructed along much the same lines, but, as in the case of other mining machinery, decided changes have been made in their design during recent years. In Fig. 1 is shown the upper part of an old type of mine pump, which has been in operation for a period of 50 years. New valves and piston cylinders have been installed from time to time, but the original method of operation is still in use at the Barnum No. 2 mine of the Pennsylvania Coal Co., Pittston, Penn.

The two plungers and cylinder are down approximately 200 ft. in the shaft. Each plunger is 15 in. in diameter and outside packed; the stroke is 6 ft. The plungers are actuated by a series of wooden plunger rods, each 8 in. wide and 6 in. thick, and they are connected by hook-and-eye straps secured to the end of each rod.

The upper end of each series of plunger rods is connected to the inner corner of a triangular walking-beam 7 ft. long on each side. The bottom corner is fitted with a shaft which oscillates in suitable bearings. The top corner of each triangle is connected to a crossarm, Fig. 1, which is 14 in. square at the center and is strengthened on both ends by an iron band which is made with an eye connection through which a pin passes as well as through corresponding holes in the angle of the walking-beam. The pump-plunger rods are connected in the same manner. The walking-beams receive motion from a rod connected with one corner of the triangle at one end and to a crank at the other. The crank is attached to a crankshaft upon which is mounted a large gear wheel at the other end. This gear meshes with a spur gear which is keyed to the engine shaft, as shown in Fig. 2. The reduction in speed between the engine and counter crankshaft gives a speed to the pump plungers of 18 strokes per minute.

The engine which operates this pump has a single eccentric and is of the old hook-valve-gear type. It was built in 1849, and, although the type of engine has become practically obsolete, this particular unit is still in good condition and performs its duty daily.

A peculiar feature is noticeable in the manner of adjusting the bearings on both the engine bearings, crankshaft and walking-beam bearings. This is accomplished by wedges which drive in from the top and are held in place by set-screws.

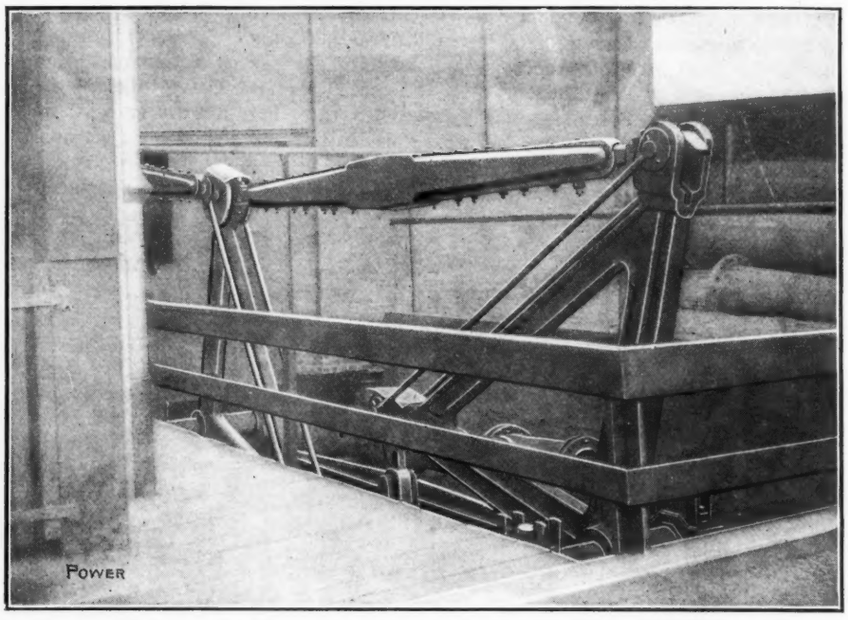


FIG. 1. UPPER WORKS OF OLD-TIME PUMP

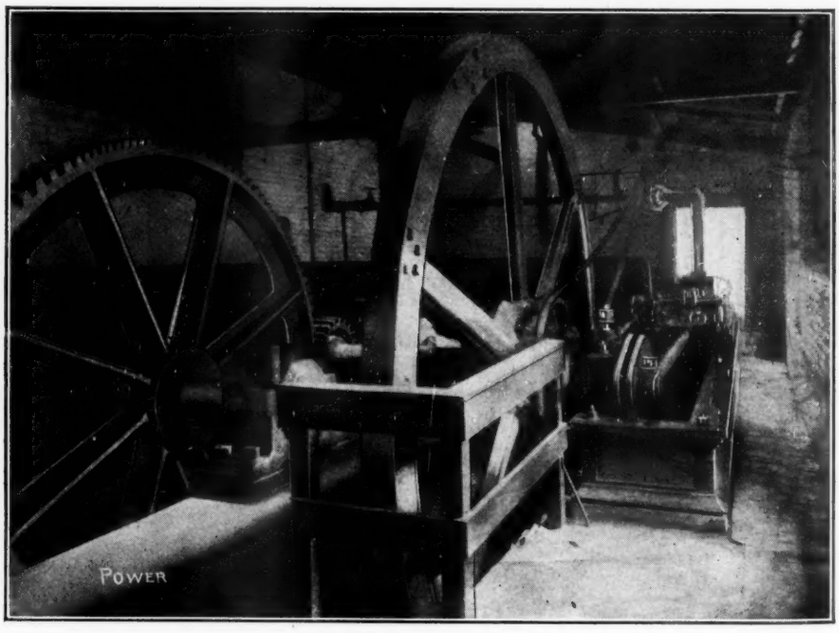


FIG. 2. OLD ENGINE WHICH OPERATES THE PUMP

A Modified Orsat Apparatus

By E. J. Billings

Many means are used for collecting samples of flue gases covering appreciable periods of time, the most common of which probably is that shown in Fig. 1, where water or brine is allowed to flow by gravity from one bottle to another, thereby drawing a sample of gas into the upper bottle. An aspirator may or may not be used with this device. Many users of flue-gas analysis apparatus do not attempt to collect continuous samples at all but analyze "instantaneous" samples or samples drawn directly from the boiler into the measuring burette of the apparatus. The Aug. 25, 1911, issue of Power, in a résumé of the Bureau of Mines Bulletin No. 12, describes a method ordinarily used in boiler tests made by the U. S. Government.

Below is a description of a combined apparatus for sampling and analyzing furnace gases as used in boiler-plant tests by Arthur D. Little, Inc., Boston. This apparatus was designed with the following points in view:

(a) To combine in a portable apparatus the sampling and analyzing devices.

(b) To find a simple means for collecting samples over any period of time up to 24 hours, which did not have the defects found in some, such as the absorption of carbon dioxide (CO_2) by the displacing liquid; the inability to always regulate the flow of liquid so as to obtain at a constant rate a sample covering the desired period; and the diffusion of gases between the sample being collected and the sampling line or boiler.

(c) To construct the apparatus so as to be compact and to contain no easily damaged parts or pieces which could not be readily replaced.

Fig. 2 shows the general plan of the apparatus designed to meet these requirements. The right half of the apparatus will be readily recognized as the ordinary Orsat apparatus, consisting mainly of three pipettes and a water-jacketed measuring burette. The left portion constitutes the sampling attachment. The gases are drawn from the sampling pipe in the flue or breeching through the rubber tube (2) into the sampling pipette (3) and out through the rubber tube (1) to the aspirator. The latter may be operated by steam or water. When a sample is being collected the three-way cock on the glass header is closed and the mercury in the sampling tube (4) is allowed to drain through the movable overflow (5) into the mercury container (7). The overflow (5) is lowered at a constant rate by clockwork (6). Two driving pulleys afford seven different rates of movement downward of the overflow (5). As the capacity of the sampling tube is 250 c.c. and only about 125 c.c. of gas at atmospheric pressure is needed for analysis, a sufficient sample may be collected at a constant rate over any period from ½ hr. to 24 hr.

To pass the gas sample collected from the sampling tube (4) into the measuring burette of the Orsat apparatus, the latter is filled with water from the leveling bottle in the usual way, the gas or air escaping through the three-way cock to the atmosphere. The upper glass cock on the sampling pipette (3) and that on the overflow (5) are closed. The mercury container (7) is then raised and set on top of the apparatus and the mercury allowed to drain back into the sampling tube (4), thereby forcing the gas through the three-way cock, previously opened, into the measuring burette. During this process the hand-leveling bottle is kept in the position shown in the illustration, and the spent gases are removed from the header by manipulating the three-way cock. To shift the sample and start the sampling apparatus to working again requires about two minutes. Instantaneous or "grab" samples may be drawn off and analyzed as often as desired and with

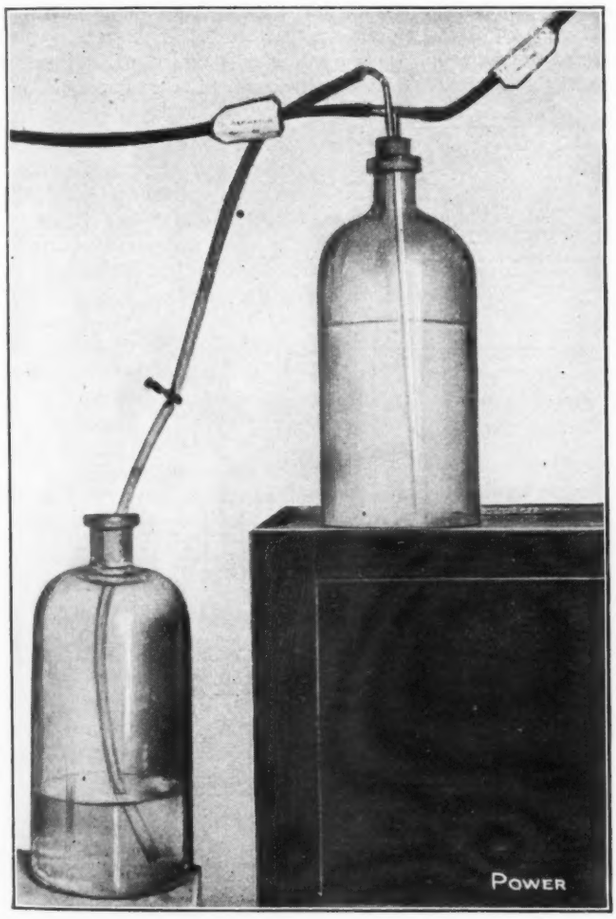


Fig. 1

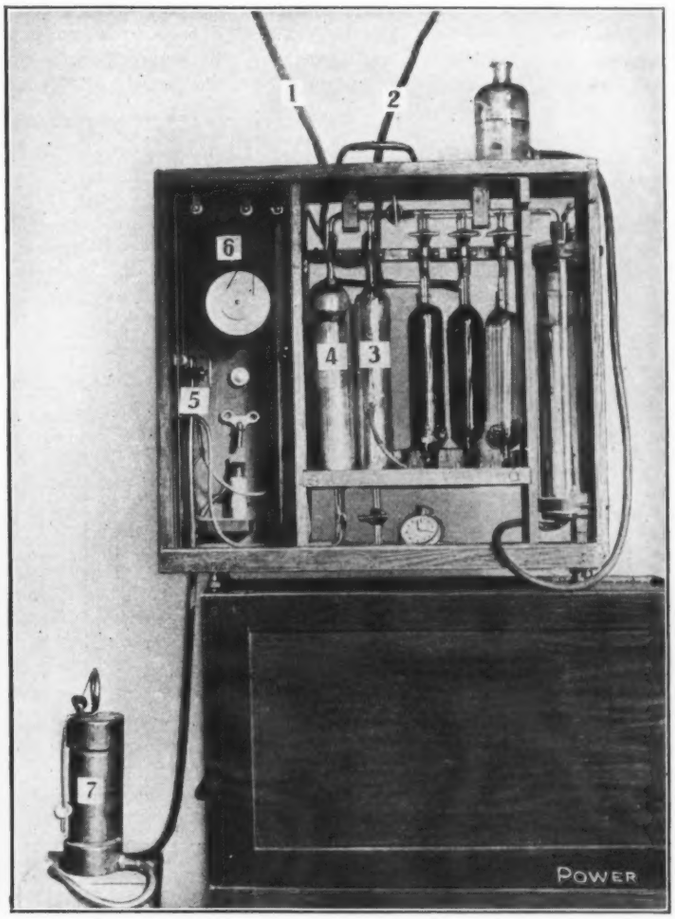


Fig. 2

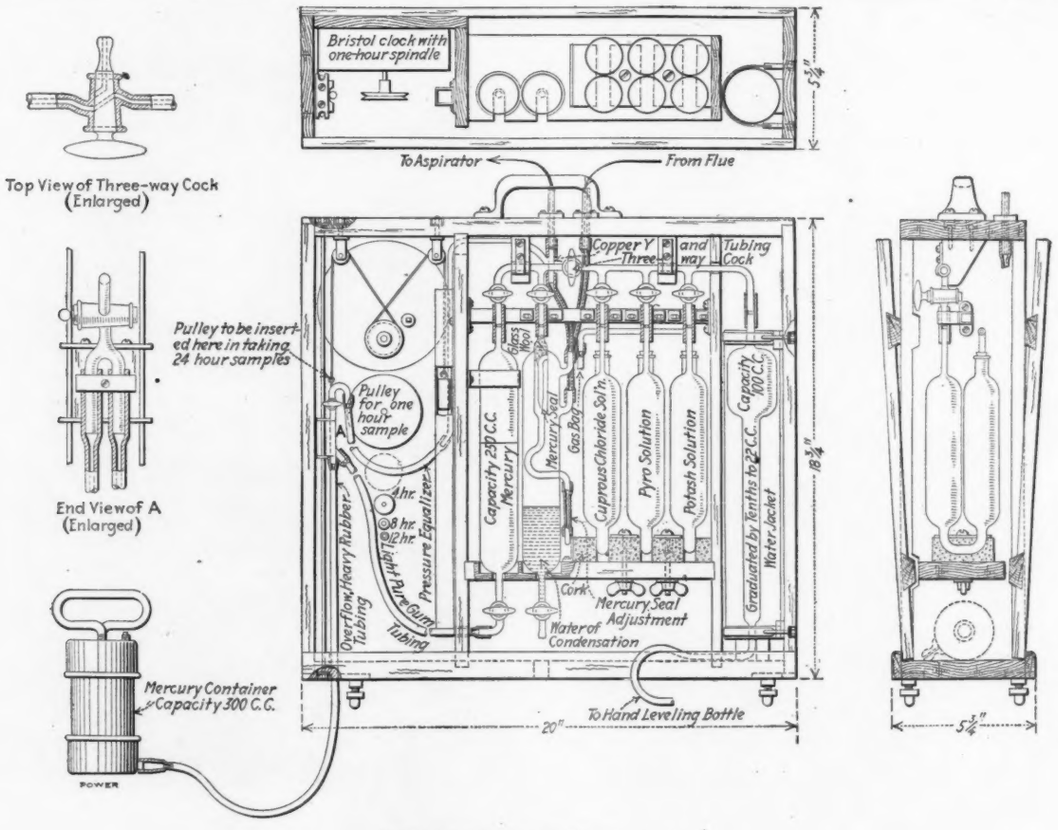
A Modified Orsat Apparatus

practically no delay to the continuous sample.

Several features in the construction of the apparatus deserve particular attention; one is a rubber-tube connection between the sampling pipette (3) and the overflow (5), which prevents unevenness in the flow of mercury due to fluctuations in draft pressure in the former. Another is the special construction of the sampling pipette (3) within which is a water seal adjustable from the outside. The gas bubbles through this seal in passing into the sampling tube (4), thereby preventing diffusion of the gases between the latter and the sampling pipette (3). Before entering the pipette from the tube (2), the gases pass through a glass wool filter which removes the soot but allows the moisture to pass on into the pipette from which it may be removed from time to time through a cock at the bottom. The measuring burette has an especially large bulb and small column, permitting graduations in tenths up to 24 c.c., which is ample for flue-gas analyses. The front cover, when in place, prevents the glass cocks jarring loose and falling out during transportation.

Much care was taken to secure the glass parts firmly and so as not to be readily broken. The apparatus has been in almost constant use for six months and but two breakages have occurred. The header broke of its own accord due to improper annealing strains and one pipette was broken in filling. The sampling device has given practically no trouble and has always been in working order.

In transportation the container, with the mercury, weighs about 15 lb. and is carried separately. The apparatus proper is 18x20x5 in. in size and weighs 21 lb.



A Modified Orsat Apparatus

Standard Flanges and Flanged Fittings

On June 17 a conference was held at the Navy Department in Washington at the request of the "Manufacturers Committee" of the makers of pipe flanges and flanged fittings to hear their protest against the adoption by the government of the "United States 1912 Standard." Present to defend it were Henry G. Stott, chairman of the committee of the American Society of Mechanical Engineers, and Henry B. Gombers, secretary of the National Association of Master Steam and Hot Water Fitters, a committee of which association worked in conjunction with that of which Mr. Stott is chairman in drawing up the 1912 standard.

The argument of the manufacturers' committee was to the effect that the standard had been adopted without sufficient notice to and discussion with them; that they have a large amount of money invested in patterns and catalogs for the present sizes, that the sizes now in use are in most cases in excess of those required by foreign standards, that they have been adopted after thorough tests and calculation and are believed to be adequate, but that if any change is to be made it should be done, in justice to the manufacturers, only after such investigation and discussion as to insure its being permanent.

Those responsible for the standard showed that they had made every reasonable attempt to interest the manufacturers in it previous to its adoption, that it represented the results of experience with and use of fittings, by those who are responsible for the erection and operation of large power plants, that each size has been thoroughly studied with regard, not only to its sufficiency, but the practicability of the design. The three principal points which were set forth were:

(1) Interchangeability of fittings in the new standard. For example, if one has a 12-in. line having a 4-in. tee on it, he can drop the fitting out and substitute another having a 6-in., 8-in., or 10-in. tee, without altering the main line. In other words, all fittings, as far as the main lines are concerned, are interchangeable, so that it is not necessary to cut or put in new lengths on the main run. This interchangeability is one of the leading points in favor of the new standard and no other standard attempts to provide it.

(2) It has been shown conclusively that when the pulling-up stresses on the

bolt, which are necessary to make a tight joint, are allowed for (leaving out of consideration the expansion and contraction stresses) the ordinary fitting, as now used, has a factor of safety of only 2 or less, while the pipe itself has a factor of safety of from 16 to 20. As a result of experiments carried out at Cornell University on the stresses placed upon the bolts in making steam-tight joints, it was found that the stresses varied inversely as the diameter of the bolt. In order to get in the larger bolts, it was necessary to enlarge the bolt circle. This, of course, meant enlarging the flange diameter.

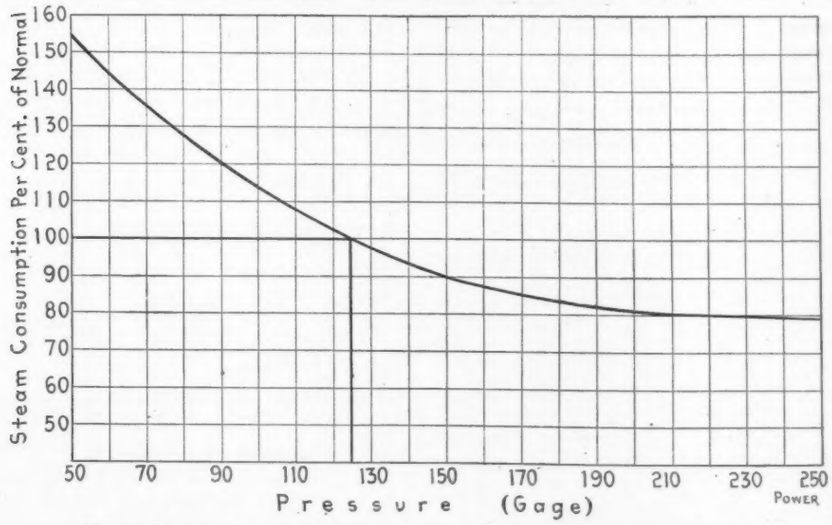
(3) The committee had in mind also that the extra-heavy fittings would in all probability be made of steel, and that too short a fitting would make a very difficult casting for the steel foundries. It is well known that it is not advisable to use cast iron with superheated steam, and as practically all turbine plants use superheated steam at a high pressure it would have been a mistake not to take this into consideration.

Mr. Sparrow, of the New York Edison Co., has conducted tests to measure the movement of a steam main, due to expansion and contraction under load conditions, which show the enormous strains put upon the flanges in the everyday work of a steam line.

If action was taken by the government authorities it has not been announced, but several of the departments are specifying the 1912 standard.

Effect of Pressure on Water Rate of Steam Turbine

The chart herewith, for which POWER is indebted to the engineers of the B. F. Sturtevant Co., shows the effect of a variation of initial pressure upon the water rate of the Sturtevant turbine.



CURVE SHOWING THE EFFECT OF PRESSURE ON THE WATER RATE OF A STEAM TURBINE

The normal pressure is taken at 125 lb., at which pressure the water rate, shown in the left-hand column, is 100 per cent. If the pressure drops to 90 lb., the steam consumption may be expected to increase to 120 per cent. of that at the normal pressure. If the pressure is increased to 220 lb., the consumption will be reduced to 80 per cent. of that at 125 lb.

Method for Filing Literature

BY LEWIS BEEBEE

Several articles giving methods for filing miscellaneous literature from papers and magazines have been published in POWER from time to time. As the writer has had a satisfactory system in service for the past two years which differs from those previously mentioned, it is believed that a detailed description of his method will prove its simplicity and completeness.

The magazines and papers from which the articles are taken should be unbound and the pages containing the articles kept whole; the remainder of the magazine or paper can be kept in a storeroom for possible future reference for some article not already selected.

The size of the cabinet, the folders and the cards will in each case need to be chosen to contain articles without folding for the specific literature to be filed, and the filing cabinet should have as many pockets as it has subjects. The standard letter-file folder of heavy material is satisfactory. The index to the file can be made up of any standard-size sheets best found in the user's line of work. The first pages in the index should contain an alphabetical list of the subjects chosen, and the pages following should be in the order of subjects indexed and numbered, and give the source from which the article was received, with the date of publication.

On the top of each folder must be printed or written the same reference name and number as the subject in the alphabetical index, as shown in Fig. 1. The cards are numbered as shown in Fig. 1 and will have the articles attached as outlined on page 1 of the index under "Air." The card shown in Fig. 2 will have the articles attached as outlined on page 2 of the index under the heading "Boilers."

The articles can be fastened to the card by any standard clip, and when a card has as many articles attached as desired, the use of the split-paper brad is very good as these articles will probably always remain attached to this individual card. To continue filing subjects under this head, the second card should have reference numbers as shown in Fig. 3.

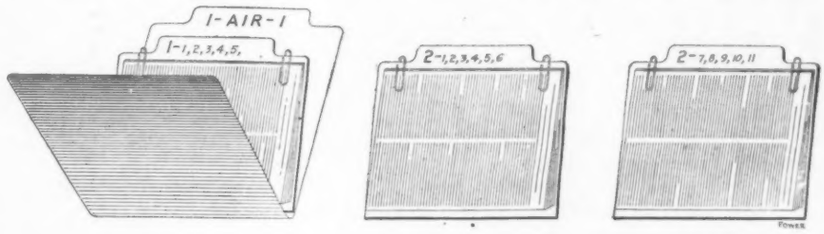


FIG. 1 FIG. 2 FIG. 3

If two subjects have the same alphabetical letter, as "Engine" and "Elevator," then index the first as follows: 5—Engines, 5A—Elevators, 5B—Etc.

When a card having a set of articles as indexed and filed under "Air" has been taken from the file, and at some later date it is desired to replace it in the filing cabinet, it is only necessary to observe the first figure, which refers to the subject and the folder, and from this reference it can be filed direct without referring to the index.

When an article is wanted, go to the index, find the subject under which the article is filed (use subject "Air"); then turn to the following itemized sheets containing the articles in this file, and when the article is found in the index, note the first number 1, which should be in larger type and have a dash between it and the following numbers, and the number 2 following the dash. Then go to the file and find the card having as its reference figures 1 — 1, 2, 3, etc., which will have the article desired.

For example, suppose an article on boilers contains some good data on bituminous coals. This article is filed under "2 — Boilers — 2" and on the card having the reference number "2 —

METHOD FOR FILING

Page 1	Subject 1—*Air*—1	Source of Article	Date
1—1	Air compressors	POWER	September 5, 1911
1—2	Air drills	POWER	
1—3	Etc.		
Page 2	*Subject* 2—*Boilers*—2	*Source of Article*	*Date*
2—1	Boiler construction	POWER	September 5, 1911
2—2	Boiler data	POWER	
2—3	Etc.		
Page 3	*Subject* 3—*Condensers*—3	*Source of Article*	*Date*
3—1	Condensers, jet type	POWER	September 5, 1911
3—2	Condensers, barometric type	POWER	
3—3	Condenser pumps		
3—4	Etc.		
Page 4	*Subject* 4—*Dust Blowers*—4	*Source of Article*	*Date*
4—1	Fan blowers, general type	POWER	September 5, 1911
4—2	Fan blowers, engine driven	POWER	
4—3	Fan blowers, h.p. required		
4—4	Etc.		
Page 5	*Subject* 5—*Engines*—5	*Source of Article*	*Date*
5—1	Engines, high speed	POWER	September 5, 1911
5—2	Engines, slow speed	POWER	
5—3	Engine horsepower		
5—4	Etc.		
Page 6	*Subject* 6—*Fuel*—6	*Source of Article*	*Date*
6—1	Fuel, anthracite	POWER	September 5, 1911
6—2	Fuel, bituminous		
6—3	Fuel compositions		
2—2	Boiler data (Cross-indexed, see explanation.)		
6—4	Etc.		

1, 2, 3, Etc.," is itemized in the index as "2 — 2." That this information may be available under bituminous coal, a reference should be made, as shown on page 6, subject "6 — Fuel — 6," as "2 — 2," boiler data. This will show that this article is a main subject on boiler data and that it contains information on this subject—Fuel.

A card index can be used in place of the sheet form, but the sheet form is handled more readily and can be placed within the file and be at hand.

The subjects would of necessity have to be chosen to cover the line of work or information desired for filing.

The accompanying table shows the method of indexing the subjects and their sources. Of course, it is to be understood that each subject chosen is to be indexed as are those given as an illustration.

Low Pressure Steam Tables*

By Lionel S. Marks

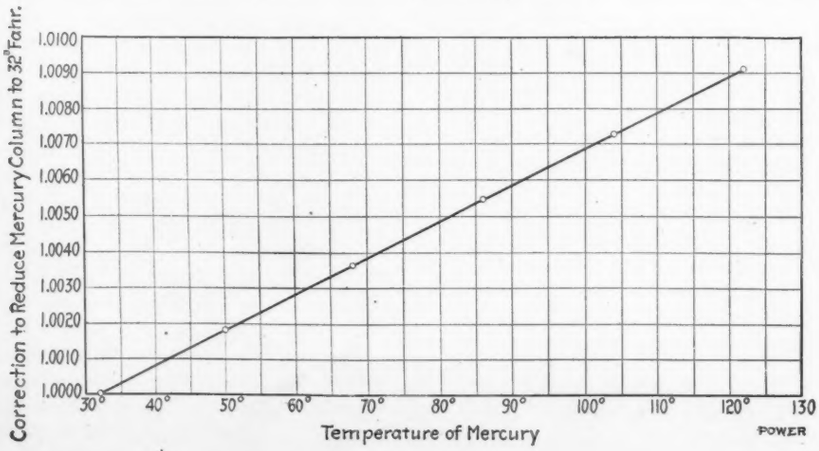
The data for condenser work are usually given in inches of mercury while the available steam tables advance by even pounds pressure and even degrees of temperature. The values for a given vacuum or pressure expressed in inches of mercury are frequently considerably different from those corresponding with the even pounds and degrees, making interpolation necessary. Prof. Marks has calculated, at our request, the following tables, giving for the pressures below that of the atmosphere the properties for even degrees, even tenths of pounds and tenth-inches of mercury.

In condenser practice, vacuums are commonly stated in inches of mercury. The vacuum is the difference between the absolute pressure of the atmosphere and that in the condenser. Knowing the atmospheric pressure as indicated by the barometer and the given or observed vacuum in inches, the absolute pressure in the condenser may be found by taking the difference.

The tables upon the following pages give the properties of dry and saturated steam at pressures which are expressed in inches of mercury as well as in pounds per square inch. Furthermore the values are given for even tenths of pounds pressure and even tenths of inches of mercury in the earlier part of the table, where the differences in the other values are considerable for comparatively small differences in temperature. The tables are an expansion of the Marks-Davis tables in this subatmospheric portion of the range and have been calculated especially for POWER by Prof. Marks.

It should be noted, however, that these pressures, as are those in the regular Marks-Davis tables, are expressed in terms of mercury at the standard temperature, 32 deg. At that temperature the standard atmosphere of 760 mm. of mercury, or of 14.696 lb. per square inch (approximately 14.7 lb.), corresponds to 29.921 in. of mercury; consequently 1 lb. per square inch corresponds to 2.036 in. of mercury, and 1 in. of mercury to 0.4902 lb. per square inch.

If the mercury is at a higher temperature its density will be less and it will take a greater height of column to balance a given pressure. If extreme accuracy is desired, the heights of the columns of mercury by which the vacuum and atmospheric pressures are measured should be reduced to their equivalent heights at 32 deg. before the subtraction is made. The accompanying chart will assist in such reduction. It is necessary simply to divide the given or observed vacuum or height by the number on the scale at the left corresponding with the height of the intersection of the line of the diagram with the ordinate representing the temperature.



As an example assume

Barometer	Mercury column on condenser	Uncorrected difference
30.42 in.	27.42 in.	3 in.

Suppose the temperature of the barometer to be 70 deg. and of the mercury column on the condenser to be 80 deg. The correction factor for 70 deg. is seen to be 1.00383 and for 80 deg. 1.00485. The corrected values would therefore be

$$\frac{30.42}{1.00383} - \frac{27.42}{1.00485} =$$

$$30.3 - 27.29 = 3.01 \text{ in.}$$

TABLE OF THE PROPERTIES OF DRY AND SATURATED STEAM AT PRESSURES BELOW THAT OF THE ATMOSPHERE—By Lionel S. Marks

Enlarged from the "Steam Tables" of Marks and Davis, with the permission of the publishers, Messrs. Longmans, Green & Co.

Temp. Fahr.	Pressure, lbs. per sq. in.	Pressure, inches of Mercury (at 32° F.)	Sp. vol., cu. ft. per lb.	Density, lbs. per cu. ft.	Heat of the Liquid	Latent Heat of Evaporation	Total Heat of Steam	External Work of Evaporation in B.t.u.	Internal energy of Evaporation	Internal energy of Steam	Entropy of Water	Entropy of Evaporation	Entropy of Steam
t	p		v	1/v	h	L	H		I	E	n	L/T	N
32.00	0.0886	0.1804	3294	0.000304	0.00	1073.4	1073.4	54.1	1019.3	1019.3	0.0000	2.1832	2.1832
34.57	0.0980	0.2000	2987	0.000335	2.59	1071.9	1074.5	54.3	1017.6	1020.2	0.0053	2.1690	2.1743
35.03	0.1000	0.2036	2935	0.000340	3.05	1071.7	1074.7	54.4	1017.3	1020.3	0.0062	2.1666	2.1728
40.00	0.1217	0.2477	2438	0.000410	8.05	1068.9	1076.9	54.9	1014.0	1022.0	0.0162	2.1394	2.1556
41.00	0.1265	0.2575	2350	0.000425	9.05	1068.3	1077.4	55.0	1013.3	1022.3	0.0182	2.1341	2.1523
42.00	0.1315	0.2677	2266	0.000441	10.06	1067.8	1077.8	55.2	1012.6	1022.7	0.0202	2.1287	2.1489
43.00	0.1366	0.2782	2185	0.000458	11.06	1067.2	1078.3	55.3	1012.0	1023.0	0.0222	2.1234	2.1456
44.00	0.1420	0.2890	2107	0.000475	12.06	1066.7	1078.7	55.4	1011.3	1023.4	0.0242	2.1181	2.1423
44.98	0.1470	0.3000	2035	0.000492	13.05	1066.2	1079.2	55.5	1010.6	1023.7	0.0262	2.1125	2.1390
45.00	0.1475	0.3002	2033	0.000492	13.07	1066.1	1079.2	55.5	1010.6	1023.7	0.0262	2.1127	2.1389
46.00	0.1532	0.3118	1961	0.000510	14.07	1065.6	1079.6	55.6	1010.0	1024.0	0.0282	2.1074	2.1356
47.00	0.1591	0.3238	1892	0.000529	15.07	1065.0	1080.1	55.7	1009.3	1024.4	0.0301	2.1022	2.1323
48.00	0.1651	0.3363	1826	0.000548	16.07	1064.5	1080.5	55.9	1008.6	1024.7	0.0321	2.0970	2.1291
49.00	0.1715	0.3492	1763	0.000567	17.08	1063.9	1081.0	56.0	1007.9	1025.0	0.0341	2.0917	2.1258
50.00	0.1780	0.3625	1702	0.000587	18.08	1063.3	1081.4	56.1	1007.3	1025.4	0.0361	2.0865	2.1226
51.00	0.1848	0.3762	1643	0.000608	19.08	1062.8	1081.9	56.2	1006.6	1025.7	0.0381	2.0814	2.1195
52.00	0.1917	0.3903	1586	0.000630	20.08	1062.2	1082.3	56.3	1006.0	1026.1	0.0401	2.0763	2.1164
52.67	0.1960	0.4000	1551	0.000645	20.75	1062.0	1082.6	56.4	1005.5	1026.3	0.0413	2.0729	2.1142
53.00	0.1989	0.4049	1532	0.000653	21.08	1061.7	1082.7	56.4	1005.3	1026.4	0.0420	2.0712	2.1132
53.15	0.2000	0.4072	1524	0.000656	21.23	1061.6	1082.8	56.5	1005.2	1026.5	0.0423	0.0704	2.1127
54.00	0.2063	0.4201	1480	0.000676	22.08	1061.1	1083.2	56.5	1004.6	1026.7	0.0440	0.0660	2.1100
55.00	0.2141	0.4357	1430	0.000700	23.08	1060.6	1083.6	56.6	1004.0	1027.1	0.0459	2.0609	2.1068
56.00	0.2219	0.4518	1381	0.000724	24.08	1060.0	1084.1	56.7	1003.3	1027.4	0.0478	0.0559	2.1037
57.00	0.2301	0.4684	1335	0.000749	25.08	1059.5	1084.5	56.8	1002.7	1027.7	0.0498	0.0508	2.1006
58.00	0.2385	0.4856	1291	0.000775	26.08	1058.9	1085.0	56.9	1002.0	1028.1	0.0517	2.0458	2.0975
58.81	0.2450	0.5000	1257	0.000792	26.89	1058.4	1085.3	57.0	1001.4	1028.3	0.0532	2.0418	2.0951
59.00	0.2472	0.5034	1249	0.000801	27.08	1058.3	1085.4	57.0	1001.3	1028.4	0.0536	2.0408	2.0944
60.00	0.2562	0.5220	1208	0.000828	28.08	1057.8	1085.9	57.1	1000.7	1028.7	0.0555	2.0358	2.0913
61.00	0.2654	0.5410	1168	0.000856	29.08	1057.2	1086.3	57.2	1000.0	1029.1	0.0574	0.0308	2.0882
62.00	0.2749	0.560	1130	0.000885	30.08	1056.7	1086.8	57.3	999.3	1029.4	0.0593	2.0258	2.0851
63.00	0.2847	0.580	1093	0.000915	31.07	1056.1	1087.2	57.4	998.7	1029.8	0.0612	2.0209	2.0821
63.95	0.2940	0.600	1060	0.000944	32.02	1055.7	1087.7	57.5	998.1	1030.1	0.0630	2.0163	2.0793
64.00	0.2949	0.601	1058	0.000946	32.07	1055.6	1087.6	57.6	998.0	1030.1	0.0631	2.0160	2.0791
64.49	0.3000	0.611	1041	0.000961	32.56	1055.3	1087.9	57.6	997.7	1030.2	0.0640	2.0136	2.0776
65.00	0.3054	0.622	1024	0.000977	33.07	1055.0	1088.1	57.7	997.4	1030.4	0.0650	2.0110	2.0760
66.00	0.3161	0.644	991	0.001009	34.07	1054.5	1088.5	57.8	996.7	1030.8	0.0669	2.0062	2.0731
67.00	0.3272	0.667	959	0.001043	35.07	1053.9	1089.0	57.9	996.0	1031.1	0.0688	2.0013	2.0701
68.00	0.3386	0.690	928	0.001077	36.07	1053.4	1089.4	58.0	995.4	1031.4	0.0707	1.9965	2.0672
68.42	0.3430	0.700	916	0.001092	36.47	1053.1	1089.6	58.0	995.1	1031.6	0.0715	1.9945	2.0660
69.00	0.3504	0.714	899	0.001112	37.06	1052.3	1089.9	58.1	994.7	1031.8	0.0726	1.9916	2.0642
70.00	0.3626	0.739	871	0.001148	38.06	1052.3	1090.3	58.3	994.0	1032.1	0.0745	1.9868	2.0613
71.00	0.3751	0.764	843	0.001186	39.06	1051.7	1090.8	58.4	993.4	1032.4	0.0764	1.9821	2.0585
72.00	0.3880	0.790	817	0.001224	40.05	1051.2	1091.2	58.5	992.7	1032.8	0.0783	1.9773	2.0556
72.37	0.3920	0.800	808	0.001238	40.42	1051.0	1091.4	58.6	992.4	1032.9	0.0790	1.9756	2.0546
72.91	0.4000	0.814	794	0.001259	40.96	1050.5	1091.5	58.6	992.1	1033.1	0.0800	1.9730	2.0530
73.00	0.4012	0.817	792	0.001263	41.05	1050.6	1091.6	58.6	992.0	1033.1	0.0802	1.9726	2.0528
74.00	0.4148	0.845	767	0.001304	42.05	1050.0	1092.1	58.7	991.4	1033.4	0.0821	1.9678	2.0499
75.00	0.4288	0.873	743	0.001346	43.05	1049.5	1092.5	58.8	990.7	1033.8	0.0840	1.9631	2.0471
75.90	0.4410	0.900	722	0.001385	43.94	1049.0	1092.9	58.8	990.2	1034.1	0.0856	1.9590	2.0446
76.00	0.4432	0.903	720	0.001389	44.04	1048.9	1093.0	58.9	990.1	1034.1	0.0858	1.9585	2.0443
77.00	0.4581	0.933	698	0.001433	45.04	1048.4	1093.4	59.0	989.4	1034.4	0.0876	1.9538	2.0414
78.00	0.4735	0.964	677	0.001477	46.04	1047.8	1093.9	59.1	988.7	1034.8	0.0895	1.9491	2.0386
79.00	0.4893	0.996	657	0.001523	47.04	1047.3	1094.3	59.2	988.1	1035.1	0.0913	1.9445	2.0358
79.12	0.4912	1.000	654	0.001529	47.16	1047.2	1094.4	59.2	988.0	1035.1	0.0915	1.9440	2.0355
79.68	0.5000	1.153	642	0.001555	47.71	1046.9	1094.6	59.3	987.6	1035.3	0.0926	1.9413	2.0339
80.00	0.505	1.029	636.8	0.001570	48.03	1046.7	1094.8	59.3	987.4	1035.4	0.0932	1.9398	2.0330
81.00	0.522	1.063	617.5	0.001619	49.03	1046.2	1095.2	59.4	986.7	1035.8	0.0950	1.9352	2.0302
82.00	0.539	1.098	598.7	0.001670	50.03	1045.6	1095.6	59.5	986.1	1036.1	0.0969	1.9306	2.0275
82.06	0.539	1.100	598.0	0.001673	50.09	1045.6	1095.7	59.5	986.1	1036.1	0.0970	1.9303	2.0273
83.00	0.557	1.134	580.5	0.001723	51.02	1045.1	1096.1	59.7	985.4	1036.4	0.0987	1.9260	2.0247
84.00	0.575	1.171	562.9	0.001777	52.02	1044.5	1096.5	59.8	984.8	1036.8	0.1005	1.9215	2.0220
84.76	0.588	1.200	550.0	0.001819	52.78	1044.1	1096.9	59.8	984.3	1037.3	0.1019	1.9180	2.0199
85.00	0.594	1.209	545.9	0.001832	53.02	1044.0	1097.0	59.9	984.1	1037.1	0.1023	1.9169	2.0192
85.32	0.600	1.222	540.0	0.001850	53.34	1043.8	1097.1	59.9	983.9	1037.2	0.1029	1.9159	2.0180
86.00	0.613	1.248	529.5	0.001889	54.01	1043.4	1097.4	60.0	983.4	1037.4	0.1041	1.9124	2.0165
87.00	0.633	1.289	513.7	0.001947	55.01	1042.8	1097.9	60.0	982.8	1037.8	0.1060	1.9079	2.0139
87.21	0.637	1.300	510.0	0.001960	55.22	1042.7	1098.0	60.1	982.7	1037.9	0.1064	1.9070	2.0134
88.00	0.654	1.331	498.4	0.002007	56.01	1042.2	1098.3	60.2	982.1	1038.1	0.1078	1.9034	2.0112
89.00	0.675	1.373	483.6	0.002068	57.00	1041.7	1098.7	60.3	981.4	1038.4	0.1096	1.8989	2.0085
89.61	0.686	1.400	474.0	0.002030	57.61	1041.4	1099.0	60.4	981.0	1038.6	0.1108	1.8962	2.0070
90.00	0.696	1.417	469.3	0.002131	58.00	1041.2	1099.2	60.4	980.8	1038.8	0.1114	1.8944	2.0058
90.18	0.700	1.425	467.0	0.002143	58.18	1041.1	1099.3	60.4	980.7	1039.9	0.1117	1.8935	2.0052
91.00	0.718	1.462	455.5	0.002195	59.00	1040.6	1099.6	60.5	980.1	1039.1	0.1133	1.8900	2.0033
91.83	0.735	1.500	444.9	0.002250	59.83	1040.1	1099.9	60.6	979.5	1039.3	0.1148	1.8863	2.0011
92.00	0.741	1.508	442.2	0.002261	60.00	1040.0	1100.1	60.6	979.4	1039.4	0.1151	1.8856	2.0007
93.00	0.765	1.556	429.4	0.002329	60.99	1039.5	1100.5	60.7	978.8	1039.8	0.1169	1.8812	1.9981
93.90	0.784	1.600	418.0	0.002391	61.90	1039.1	1101.0	60.8	978.2	1040.1	0.1185	1.8771	1.9956
94.00	0.789	1.605	417.0	0.002398	61.99	1039.0	1101.0	60.9	978.1	1040.1	0.1187	1.8767	1.9954
94.46	0.800	1.629	411.0	0.002431	62.45	1038.7	1101.2	60.9	977.8	1040.2	0.1195	1.8747	1.9942
95.00	0.813	1.655	405.0	0.002469	62.99	1038.4	1101.4	61.0	977.4	1040.4	0.1205	1.8723	1.9928
95.88	0.833	1.700	394.8	0.002533	63.86	1037.9	1101.7	61.0	976.9	1040.7	0.1221	1.8685	1.9906
96.00	0.838	1.706	393.4	0.002542	63.98	1037.8	1101.8	61.0	976.8	1040.8	0.1223	1.8680	1.9903
97.00	0.864	1.759	382.2	0.002617	64.98	1037.3	1102.3	61.1	976.1	1041.1	0.1241	1.8636	1.9877
97.76	0.882	1.800	374.0	0.002675	65.74	1036.8	1102.5	61.2	975.6	1041.3	0.1255	1.8603	1.9858
98.00	0.891	1.813	371.4	0.002693	65.98	1036.7	1102.8	61.2	975.5	1041.4	0.1259	1.8592	1.9851
98.33	0.900	1.832	367.9	0.002719	66.31	1036.5	1102.8	61.3	975.3	1041.5	0.1265	1.8578	1.9843
99.00	0.918	1.869	360.9	0.002771	66.97	1036.2	1103.2	61.4	974.8	1041.8	0.1277	1.8549	1.9826
99.50	0.931	1.900	355.9	0.002811	67.47	1035.9	1103.4	61.4	974.5	1041.9	0.1286	1.8527	1.9813
100.00	0.946	1.926	350.8	0.002851	67.97	1035.6	1103.6	61.5	974.1	1042.1	0.1295	1.8505	1.9800
101.00	0.975	1.985	341.0	0.002933	68.97	1035.1	1104.0	61.6	973.5	1042.4	0.1313	1.8463	1.9776
101.25	0.980	2.000	338.6	0.002954	69.22	1035.0	1104.9	61.7	973.3	1042.5	0.1317	1.8452	1.9769
101.84	1.000	2.036	333.0	0.003000	69.80	1034.6	1104.4	61.7	972.9	1042.7	0.1327	1.8427	1.9754
102.00	1.005	2.045	331.5	0.003017	69.96	1034.5	1104.5	61.8	972.8	1042.8	0.1330	1.8420	1.9750
102.89	1.029	2.100	323.4	0.003095	70.85	1034.1	1104.9	61.8	972.2	1043.1	0.1345	1.8382	1.9727
103.00	1.035	2.107	322.2	0.003104	70.96	1034.0	1104.9	61.9	972.1	1043.1	0.1347	1.8377	1.9724
104.00	1.066	2.171	313.3	0.003192	71.96	1033.4	1105.3	61.9	971.5	1043.4	0.1365	1.8335	1.9700
104.45	1.078	2.200	309.4	0.003232	72.40	1033.1	1105.5	61.9	971.2	1043.6	0.1373	1.8316	1.9689
105.00	1.098	2.236	304.7	0.003282	72.95	1032.8	1105.8	62.0	970.8	1043.8	0.1383	1.8292	1.9675
105.06	1.100	2.240	304.2	0.003287	73.01	1032.8	1105.8	62.0	970.8	1043.8	0.1384	1.8289	1.9673
105.55	1.127	2.300	300.1	0.003330	73.50	1032.5	1106.0	62.1	970.4	1044.0	0.1393	1.8269	1.9662
106.00	1.131	2.303	296.4	0.003374	73.95	1032.3	1106.2	62.1	970.1	1044.1	0.1401	1.8250	1.9651
107.00	1.165	2.372	288.3	0.003469	74.95	1031.7	1106.7	62.2	969.5	1044.4	0.1418	1.8208	1.9626
107.40	1.176	2.400	285.2	0.003507	75.35	1031.5	1106.8	62.3	969.2	1044.6	0.1425	1.8191	1.9616
108.00	1.199	2.443	280.5	0.003565	75.95	1031.2	1107.1	62.3	968.8	1044.8	0.1436	1.8166	1.9602
108.03	1.200	2.443	280.3	0.003568	75.98	1031.2	1107.2	62.4	968.8	1044.8	0.1437	1.8165	1.9602
108.80	1.225	2.500	274.1	0.003644	76.73	1030.7	1107.4	62.4	968.3	1045.0	0.1450	1.8133	1.9583
109.00	1.235	2.515	272.9	0.003664	76.94	1030.6	1107.5	62.4	968.2	1045.1	0.1454	1.8124	1.9578
110.00	1.271	2.589	265.5	0.003766	77.94	1030.0	1108.0	62.5	967.5	1045.4	0.1471	1.8082	1.9553
110.15	1.274	2.600	264.4	0.003782	78.09	1029.9	1108.1	62.5	967.4	1045.5	0.1474	1.8076	1.9550
110.79	1.300	2.647	259.1	0.003859	78.83	1029.6	1108.3	62.6	966.9	1045.7	0.1487	1.8046	1.9533

TABLE OF THE PROPERTIES OF DRY AND SATURATED STEAM AT PRESSURES BELOW THAT OF THE ATMOSPHERE—By Lionel S. Marks—(Continued)

Temp. Fahr.	Pressure, lbs. per sq. in.	Pressure, inches of Mercury (at 32° F.)	Sp. vol., cu. ft. per lb.	Density, lbs. per cu. ft.	Heat of the Liquid	Latent Heat of Evaporation	Total Heat of Steam	External Work of Evaporation in B.t.u.	Internal energy of Evaporation	Internal energy of Steam	Entropy of Water	Entropy of Evaporation	Entropy of Steam
t	p		v	1/v	h	L	H		I	E	n	L/T	N
111.00	1.308	2.665	258.3	0.003871	78.94	1029.5	1108.4	62.6	966.8	1045.8	0.1489	1.8041	1.9530
111.47	1.323	2.700	255.2	0.003921	79.40	1029.2	1108.6	62.7	966.6	1045.9	0.1497	1.8022	1.9519
112.00	1.346	2.740	251.4	0.003978	79.93	1028.9	1108.8	62.7	966.2	1046.1	0.1506	1.8000	1.9506
112.73	1.372	2.800	246.5	0.004058	80.66	1028.5	1109.2	62.8	965.7	1046.3	0.1519	1.7970	1.9489
113.00	1.386	2.822	244.7	0.004087	80.93	1028.4	1109.3	62.9	965.5	1046.4	0.1524	1.7959	1.9483
113.35	1.400	2.850	242.4	0.004126	81.28	1028.2	1109.5	62.9	965.3	1046.5	0.1530	1.7944	1.9474
113.95	1.421	2.900	238.5	0.004192	81.88	1027.8	1109.7	63.0	964.8	1046.8	0.1540	1.7919	1.9459
114.00	1.426	2.904	238.2	0.004198	81.93	1027.8	1109.7	63.0	964.8	1046.8	0.1541	1.7917	1.9458
115.00	1.467	2.987	231.9	0.004312	82.92	1027.2	1110.2	63.0	964.2	1047.1	0.1559	1.7876	1.9435
115.15	1.470	3.000	239.0	0.004330	83.07	1027.1	1110.2	63.0	964.1	1047.1	0.1562	1.7870	1.9432
115.79	1.500	3.054	227.1	0.004404	83.71	1026.8	1110.5	63.1	963.5	1047.3	0.1572	1.7844	1.9417
116.00	1.509	3.073	225.8	0.004429	83.92	1026.7	1110.6	63.1	963.5	1047.4	0.1576	1.7836	1.9412
116.31	1.519	3.100	224.0	0.004466	84.23	1026.5	1110.7	63.2	963.3	1047.5	0.1582	1.7823	1.9405
117.00	1.553	3.161	219.9	0.004548	84.92	1026.1	1111.0	63.2	962.8	1047.8	0.1594	1.7795	1.9389
117.43	1.568	3.200	217.4	0.004601	85.35	1025.8	1111.1	63.3	962.5	1047.9	0.1601	1.7778	1.9379
118.00	1.597	3.252	214.1	0.004671	85.92	1025.5	1111.5	63.3	962.2	1048.1	0.1611	1.7755	1.9366
118.07	1.600	3.258	213.8	0.004630	85.99	1025.5	1111.5	63.4	962.2	1048.1	0.1613	1.7752	1.9365
118.52	1.617	3.300	211.2	0.004736	86.44	1025.2	1111.6	63.4	961.8	1048.3	0.1620	1.7734	1.9354
119.00	1.642	3.344	208.5	0.004796	86.91	1025.0	1111.9	63.5	961.5	1048.4	0.1628	1.7715	1.9343
119.60	1.665	3.400	205.3	0.004873	87.51	1024.6	1112.1	63.5	961.1	1048.6	0.1638	1.7690	1.9328
120.00	1.689	3.438	203.1	0.004924	87.91	1024.4	1112.3	63.6	960.8	1048.7	0.1645	1.7674	1.9319
120.23	1.700	3.461	201.9	0.004954	88.14	1024.3	1112.4	63.6	960.7	1048.8	0.1649	1.7665	1.9314
120.64	1.715	3.500	199.8	0.005007	88.55	1024.1	1112.6	63.7	960.4	1048.9	0.1656	1.7648	1.9304
121.00	1.736	3.535	197.9	0.005054	88.91	1023.9	1112.8	63.7	960.2	1049.1	0.1662	1.7634	1.9296
121.65	1.764	3.600	194.6	0.005140	89.56	1023.5	1113.1	63.8	959.7	1049.3	0.1673	1.7508	1.9281
122.00	1.785	3.635	192.8	0.005187	89.91	1023.3	1113.2	63.8	959.5	1049.4	0.1679	1.7594	1.9273
122.30	1.800	3.665	191.3	0.005228	90.21	1023.2	1113.4	63.9	959.3	1049.5	0.1684	1.7582	1.9266
122.65	1.812	3.700	189.7	0.005274	90.54	1023.0	1113.5	63.9	959.1	1049.6	0.1690	1.7569	1.9259
123.00	1.835	3.737	187.9	0.005323	90.90	1022.7	1113.6	63.9	958.8	1049.7	0.1696	1.7555	1.9251
123.61	1.862	3.800	185.0	0.005408	91.51	1022.4	1113.9	64.0	958.4	1049.9	0.1706	1.7531	1.9237
124.00	1.886	3.841	183.1	0.005462	91.90	1022.2	1114.1	64.0	958.2	1050.0	0.1713	1.7515	1.9228
124.25	1.900	3.868	181.9	0.005498	92.15	1022.1	1114.2	64.1	958.0	1050.1	0.1717	1.7505	1.9222
124.55	1.911	3.900	180.5	0.005541	92.45	1021.9	1114.3	64.1	957.8	1050.2	0.1722	1.7493	1.9215
125.00	1.938	3.948	178.4	0.005605	92.90	1021.6	1114.5	64.2	957.5	1050.4	0.1730	1.7475	1.9205
125.48	1.960	4.000	176.2	0.005675	93.38	1021.3	1114.7	64.2	957.2	1050.5	0.1738	1.7457	1.9195
126.00	1.992	4.057	173.9	0.005751	93.90	1021.1	1115.0	64.3	956.8	1050.7	0.1747	1.7436	1.9183
126.15	2.000	4.072	173.5	0.005760	94.00	1021.0	1115.0	64.3	956.7	1050.7	0.1748	1.7431	1.9180
126.39	2.009	4.100	172.3	0.005809	94.28	1020.9	1115.2	64.4	956.5	1050.8	0.1754	1.7421	1.9175
127.00	2.047	4.168	169.6	0.005900	94.89	1020.5	1115.4	64.4	956.1	1051.0	0.1764	1.7397	1.9161
127.28	2.058	4.200	168.2	0.005943	95.17	1020.3	1115.5	64.4	955.9	1051.1	0.1769	1.7384	1.9155
127.94	2.100	4.276	165.6	0.006043	95.83	1019.9	1115.7	64.4	955.5	1051.3	0.1780	1.7360	1.9140
128.00	2.103	4.282	165.3	0.006052	95.89	1019.9	1115.8	64.5	955.5	1051.3	0.1781	1.7358	1.9139
128.16	2.107	4.300	164.7	0.006077	96.05	1019.8	1115.9	64.5	955.4	1051.4	0.1784	1.7352	1.9136
129.00	2.160	4.399	161.1	0.006207	96.89	1019.4	1116.2	64.6	954.8	1051.7	0.1799	1.7318	1.9117
129.01	2.156	4.400	161.1	0.006209	96.90	1019.4	1116.2	64.6	954.8	1051.7	0.1799	1.7318	1.9117
129.68	2.200	4.479	158.4	0.006320	97.57	1019.0	1116.5	64.6	954.4	1051.9	0.1811	1.7291	1.9102
129.84	2.205	4.500	157.8	0.006344	97.73	1018.9	1116.6	64.7	954.2	1051.9	0.1813	1.7286	1.9099
130.00	2.219	4.520	157.1	0.006370	97.89	1018.8	1116.7	64.7	954.1	1052.0	0.1816	1.7279	1.9095
130.67	2.254	4.600	154.5	0.006480	98.56	1018.4	1117.0	64.8	953.6	1052.2	0.1827	1.7253	1.9080
131.00	2.279	4.640	153.2	0.006530	98.89	1018.2	1117.1	64.8	953.4	1052.3	0.1833	1.7240	1.9073
131.35	2.300	4.68	151.9	0.00659	99.24	1018.6	1117.2	64.8	953.2	1052.4	0.1839	1.7227	1.9066
131.50	2.303	4.70	151.3	0.00661	99.38	1018.9	1117.3	64.9	953.1	1052.2	0.1841	1.7221	1.9062
132.00	2.340	4.76	149.4	0.00669	99.88	1017.7	1117.5	64.9	952.8	1052.7	0.1849	1.7202	1.9051
132.31	2.352	4.80	148.3	0.00674	100.18	1017.5	1117.7	64.9	952.6	1052.8	0.1854	1.7191	1.9045
132.96	2.400	4.88	145.9	0.00685	100.84	1017.1	1117.9	65.0	952.1	1053.0	0.1865	1.7166	1.9031
133.00	2.403	4.89	145.8	0.00686	100.88	1017.1	1118.0	65.0	952.1	1053.0	0.1866	1.7164	1.9030
133.08	2.401	4.90	145.5	0.00687	100.96	1017.0	1118.0	65.0	952.0	1053.0	0.1867	1.7161	1.9028
133.85	2.450	5.00	142.7	0.00700	101.73	1016.6	1118.3	65.1	951.5	1053.3	0.1881	1.7130	1.9011
134.00	2.467	5.02	142.2	0.00703	101.88	1016.5	1118.4	65.1	951.4	1053.3	0.1883	1.7125	1.9008
134.49	2.500	5.09	140.5	0.00712	102.37	1016.3	1118.7	65.2	951.1	1053.4	0.1891	1.7106	1.8997
135.00	2.533	5.16	138.7	0.00721	102.88	1016.0	1118.8	65.2	950.8	1053.6	0.1900	1.7086	1.8986
136.00	2.600	5.29	135.4	0.00739	103.88	1015.4	1119.3	65.3	950.1	1054.0	0.1917	1.7048	1.8965
137.00	2.669	5.43	132.1	0.00757	104.87	1014.8	1119.7	65.4	949.4	1054.3	0.1933	1.7010	1.8943
137.44	2.700	5.50	130.6	0.00765	105.31	1014.6	1119.9	65.5	949.1	1054.4	0.1940	1.6993	1.8933
138.00	2.740	5.58	128.9	0.00776	105.87	1014.3	1120.1	65.5	948.8	1054.6	0.1950	1.6972	1.8922
138.83	2.800	5.70	126.3	0.00792	106.70	1013.8	1120.5	65.6	948.2	1054.9	0.1964	1.6941	1.8905
139.00	2.812	5.73	125.8	0.00795	106.87	1013.7	1120.6	65.6	948.1	1055.0	0.1967	1.6934	1.8901
140.00	2.885	5.88	122.8	0.00814	107.87	1013.1	1121.0	65.7	947.4	1055.3	0.1984	1.6896	1.8880
140.43	2.900	5.90	121.6	0.00821	108.30	1012.9	1121.2	65.8	947.1	1055.4	0.1991	1.6880	1.8871
140.80	2.940	6.00	120.5	0.00830	108.67	1012.7	1121.4	65.8	946.9	1055.5	0.1997	1.6864	1.8861
141.00	2.960	6.03	119.9	0.00834	108.87	1012.6	1121.4	65.8	946.8	1055.6	0.2000	1.6859	1.8859
141.52	3.000	6.11	118.5	0.00845	109.40	1012.3	1121.6	65.9	946.4	1055.8	0.2008	1.6840	1.8848
142.00	3.037	6.18	117.1	0.00854	109.87	1012.0	1121.8	65.9	946.1	1055.9	0.2017	1.6821	1.8838
142.81	3.100	6.31	114.8	0.00871	110.78	1011.5	1122.3	66.0	945.5	1056.2	0.2030	1.6791	1.8821
143.00	3.115	6.34	114.3	0.00875	110.87	1011.4	1122.3	66.0	945.4	1056.3	0.2033	1.6774	1.8817
144.00	3.195	6.51	111.6	0.00896	111.87	1010.8	1122.7	66.1	944.7	1056.6	0.2050	1.6746	1.8796
144.06	3.200	6.52	111.4	0.00909	111.93	1010.8	1122.7	66.1	944.7	1056.6	0.2051	1.6746	1.8797
145.00	3.277	6.67	109.0	0.00918	112.86	1010.3	1123.1	66.2	944.0	1056.9	0.2067	1.6709	1.8776
145.27	3.300	6.72	108.3	0.00924	113.13	1010.1	1123.2	66.3	943.8	1057.0	0.2071	1.6698	1.8769
146.00	3.361	6.84	106.5	0.00940	113.86	1009.7	1123.6	66.3	943.4	1057.2	0.2083	1.6672	1.8755
146.46	3.400	6.92	105.3	0.00950	114.32	1009.4	1123.7	66.3	943.1	1057.4	0.2091	1.6655	1.8746
146.89	3.430	7.00	104.3	0.00960	114.74	1009.2	1124.0	66.4	942.8	1057.6	0.2098	1.6639	1.8737
147.00	3.446	7.02	104.0	0.00962	114.86	1009.1	1124.0	66.4	942.7	1057.6	0.2100	1.6635	1.8735
147.62	3.500	7.12	102.5	0.00976	115.48	1008.8	1124.3	66.5	942.3	1057.8	0.2110	1.6606	1.8716
148.00	3.533	7.20	101.6	0.00985	115.86	1008.6	1124.4	66.6	942.0	1057.9	0.2116	1.6598	1.8714
148.75	3.600	7.33	99.8	0.01002	116.61	1008.2	1124.8	66.6	941.6	1058.1	0.2128	1.6571	1.8699
149.00	3.623	7.38	99.2	0.01008	116.86	1008.0	1124.8	66.6	941.4	1058.2	0.2132	1.6562	1.8694
149.85	3.700	7.53	97.2	0.01028	117.71	1007.5	1125.2	66.7	940.8	1058.5	0.2146	1.6531	1.8677
150.00	3.714	7.57	96.9	0.01032	117.86	1007.4	1125.3	66.7	940.7	1058.5	0.2149	1.6525	1.8674
150.91	3.800	7.73	94.9	0.01054	118.77	1006.9	1125.7	66.8	940.1	1058.8	0.2164	1.6492	1.8656
151.00	3.809	7.76	94.7	0.01056	118.86	1006.8	1125.7	66.8	940.0	1058.8	0.2165	1.6488	1.8653
151.79	3.900	7.93	93.0	0.01075	119.65	1006.3	1126.0	66.9	939.5	1059.1	0.2178	1.6460	1.8638
152.00	3.902	7.95	92.6	0.01080	119.86	1006.2	1126.1	66.9	939.3	1059.2	0.2182	1.6452	1.8634
152.27	3.920	8.00	92.0	0.01087	120.12	1006.1	1126.2	67.0	939.1	1059.3	0.2186	1.6443	1.8629
153.00	3.999	8.14	90.5	0.01105	120.86	1005.7	1126.5	67.1	938.6	1059.5	0.2198	1.6416	1.8614
153.01	4.000	8.14	90.5	0.01107	120.90	1005.7	1126.5	67.1	938.6	1059.5	0.2198	1.6416	1.8614
154.00	4.098	8.34	88.4	0.01131	121.86	1005.1	1127.0	67.1	938.0	1059.8	0.2214	1.6380	1.8594
154.02	4.100	8.35	88.4	0.01131	121.86	1005.1	1127.0	67.2	938.0	1059.8	0.2214	1.6380	1.8594
155.00	4.199	8.55	86.4	0.01157	122.86	1004.5	1127.4	67.2	937.3	1060.2	0.2231	1.6344	1.8575
155.02	4.200	8.55	86.4	0.01157	122.86	1004.5	1127.4	67.2	937.3	1060.2	0.2231	1.6344	1.8575

TABLE OF THE PROPERTIES OF DRY AND SATURATED STEAM AT PRESSURES BELOW THAT OF THE ATMOSPHERE—By Lionel S. Marks—(Concluded)

Temp. Fahr.	Pressure, lbs. per sq. in.	Pressure, inches of Mercury (at 32° F.)	Sp. vol., cu. ft. per lb.	Density, lbs. per cu. ft.	Heat of the Liquid	Latent Heat of Evaporation	Total Heat of Steam	External Work of Evaporation in B.t.u.	Internal energy of Evaporation	Internal energy of Steam	Entropy of Water	Entropy of Evaporation	Entropy of Steam
t	p		v	1/v	h	L	H		I	E	n	L/T	N
155.97	4.300	8.75	84.6	0.01183	123.83	1004.0	1127.8	67.3	936.6	1060.5	0.2246	1.6309	1.8556
156.00	4.303	8.76	84.5	0.01184	123.86	1003.9	1127.8	67.3	936.6	1060.5	0.2247	1.6308	1.8555
156.93	4.400	8.96	82.7	0.01209	124.79	1003.4	1128.2	67.4	936.0	1060.8	0.2262	1.6275	1.8537
157.00	4.408	8.98	82.6	0.01211	124.86	1003.4	1128.2	67.4	935.9	1060.8	0.2263	1.6272	1.8535
157.10	4.410	9.00	82.4	0.01213	124.95	1003.3	1128.2	67.5	935.8	1060.8	0.2264	1.6269	1.8533
157.86	4.500	9.16	81.0	0.01234	125.72	1002.8	1128.5	67.5	935.3	1061.1	0.2277	1.6241	1.8518
158.00	4.515	9.20	80.7	0.01239	125.86	1002.8	1128.6	67.5	935.3	1061.1	0.2279	1.6236	1.8515
158.77	4.600	9.36	79.3	0.01260	126.63	1002.4	1129.0	67.6	934.8	1061.4	0.2291	1.6209	1.8500
159.00	4.625	9.42	78.9	0.01267	126.86	1002.2	1129.1	67.6	934.6	1061.5	0.2295	1.6201	1.8496
159.67	4.700	9.57	77.8	0.01286	127.53	1001.9	1129.4	67.7	934.1	1061.7	0.2306	1.6177	1.8483
160.00	4.737	9.67	77.2	0.01296	127.86	1001.6	1129.5	67.7	933.9	1061.8	0.2311	1.6165	1.8476
160.55	4.800	9.77	76.3	0.01312	128.41	1001.3	1129.7	67.8	933.5	1061.96	0.2320	1.6146	1.8466
161.00	4.851	9.88	75.5	0.01325	128.86	1001.1	1129.9	67.8	933.3	1062.1	0.2327	1.6130	1.8457
161.42	4.900	10.00	74.8	0.01340	129.28	1000.8	1130.1	67.8	933.0	1062.2	0.2334	1.6115	1.8449
161.50	4.900	10.00	74.7	0.01340	129.36	1000.8	1130.2	67.9	933.1	1062.3	0.2335	1.6112	1.8447
162.00	4.967	10.12	73.8	0.01355	129.86	1000.5	1130.4	67.9	932.6	1062.4	0.2344	1.6094	1.8438
162.28	5.000	10.18	73.3	0.01364	130.10	1000.3	1130.5	68.0	932.4	1062.5	0.2348	1.6084	1.8432
163.00	5.086	10.36	72.2	0.01386	130.86	999.9	1130.8	68.1	931.9	1062.8	0.2360	1.6059	1.8419
164.00	5.208	10.61	70.6	0.01417	131.86	999.3	1131.2	68.1	931.2	1063.1	0.2376	1.6024	1.8400
165.00	5.333	10.86	69.1	0.01448	132.86	998.7	1131.6	68.2	930.5	1063.4	0.2391	1.5989	1.8380
165.54	5.390	11.00	68.3	0.01465	133.4	998.4	1131.8	68.3	930.1	1063.5	0.2400	1.5970	1.8370
166.00	5.460	11.12	67.6	0.01480	133.86	998.2	1132.0	68.4	929.8	1063.7	0.2407	1.5954	1.8361
167.00	5.589	11.38	66.1	0.01513	134.86	997.6	1132.4	68.5	929.1	1064.0	0.2423	1.5919	1.8342
168.00	5.721	11.65	64.7	0.01546	135.86	997.0	1132.8	68.6	928.4	1064.3	0.2439	1.5885	1.8324
169.00	5.855	11.92	63.3	0.01580	136.86	996.4	1133.3	68.6	927.8	1064.6	0.2455	1.5850	1.8305
169.29	5.880	12.00	62.9	0.01596	137.15	996.3	1133.4	68.7	927.6	1064.7	0.2459	1.5841	1.8300
170.00	5.992	12.20	62.0	0.01614	137.87	995.8	1133.7	68.7	927.1	1064.9	0.2470	1.5816	1.8286
170.06	6.000	12.22	61.9	0.01616	137.90	995.8	1133.7	68.8	927.0	1064.9	0.2471	1.5814	1.8285
171.00	6.131	12.48	60.7	0.01649	138.87	995.2	1134.1	68.8	926.4	1065.2	0.2486	1.5782	1.8268
172.00	6.273	12.77	59.4	0.01685	139.87	994.6	1134.5	68.9	925.7	1065.6	0.2502	1.5747	1.8249
172.67	6.370	13.00	58.5	0.01709	140.56	994.2	1134.8	69.0	925.2	1065.8	0.2513	1.5724	1.8237
173.00	6.417	13.07	58.1	0.01721	140.87	994.0	1134.9	69.0	925.0	1065.9	0.2518	1.5713	1.8231
174.00	6.564	13.37	56.9	0.01758	141.87	993.5	1135.3	69.1	924.3	1066.2	0.2534	1.5679	1.8213
175.00	6.714	13.67	55.7	0.01796	142.87	992.9	1135.7	69.2	923.6	1066.5	0.2550	1.5645	1.8195
176.00	6.867	13.98	54.5	0.01834	143.87	992.3	1136.2	69.3	923.0	1066.8	0.2565	1.5611	1.8176
176.06	6.860	14.00	54.4	0.01836	143.88	992.3	1136.2	69.3	923.0	1066.8	0.2566	1.5609	1.8175
176.85	7.000	14.25	53.6	0.01867	144.70	991.8	1136.5	69.4	922.4	1067.1	0.2579	1.5582	1.8161
177.00	7.023	14.30	53.4	0.01873	144.88	991.7	1136.6	69.4	922.3	1067.1	0.2581	1.5577	1.8158
178.00	7.182	14.62	52.3	0.01912	145.88	991.1	1137.0	69.5	921.6	1067.5	0.2597	1.5543	1.8140
179.00	7.344	14.95	51.2	0.01953	146.88	990.5	1137.4	69.6	920.9	1067.8	0.2612	1.5510	1.8122
179.15	7.350	15.00	51.0	0.01959	147.03	990.5	1137.5	69.7	920.8	1067.8	0.2614	1.5505	1.8119
180.00	7.51	15.29	50.2	0.01994	147.88	989.9	1137.8	69.7	920.2	1068.1	0.2628	1.5476	1.8104
181.00	7.68	15.63	49.1	0.02036	148.88	989.3	1138.2	69.8	919.5	1068.4	0.2644	1.5443	1.8087
182.00	7.85	15.98	48.1	0.02078	149.89	988.7	1138.6	69.9	918.8	1068.7	0.2659	1.5409	1.8068
182.05	7.84	16.00	48.1	0.02080	149.94	988.7	1138.6	69.9	918.8	1068.7	0.2660	1.5407	1.8067
182.86	8.00	16.29	47.3	0.02115	150.80	988.2	1139.0	70.0	918.2	1069.0	0.2673	1.5380	1.8054
183.00	8.02	16.34	47.2	0.02121	150.89	988.1	1139.0	70.0	918.1	1069.0	0.2675	1.5376	1.8051
184.00	8.20	16.70	46.2	0.02165	151.89	987.5	1139.4	70.1	917.4	1069.3	0.2690	1.5343	1.8033
184.80	8.33	17.00	45.4	0.02201	152.70	987.0	1139.7	70.2	916.8	1069.5	0.2703	1.5316	1.8019
185.00	8.38	17.07	45.3	0.02210	152.89	986.9	1139.8	70.2	916.7	1069.6	0.2706	1.5310	1.8016

Temp. Fahr.	Pressure, lbs. per sq. in.	Pressure, inches of Mercury (at 32° F.)	Sp. vol., cu. ft. per lb.	Density, lbs. per cu. ft.	Heat of the Liquid	Latent Heat of Evaporation	Total Heat of Steam	External Work of Evaporation in B.t.u.	Internal energy of Evaporation	Internal energy of Steam	Entropy of Water	Entropy of Evaporation	Entropy of Steam
t	p		v	1/v	h	L	H		I	E	n	L/T	N
186.00	8.57	17.45	44.3	0.02255	153.89	986.3	1140.2	70.3	916.0	1069.9	0.2721	1.5277	1.7998
187.00	8.76	17.83	43.5	0.02301	154.90	985.7	1140.6	70.4	915.3	1070.2	0.2737	1.5244	1.7981
187.44	8.82	18.00	43.1	0.02321	155.34	985.5	1140.8	70.5	915.0	1070.3	0.2744	1.5229	1.7973
188.00	8.95	18.22	42.6	0.02348	155.90	985.1	1141.0	70.5	914.6	1070.5	0.2752	1.5211	1.7963
188.27	9.00	18.32	42.4	0.02361	156.20	985.0	1141.1	70.6	914.4	1070.5	0.2756	1.5202	1.7958
189.00	9.14	18.61	41.74	0.02396	156.90	984.5	1141.4	70.6	913.9	1070.8	0.2767	1.5179	1.7946
189.95	9.31	19.00	40.94	0.02438	157.87	983.9	1141.8	70.6	913.3	1071.1	0.2782	1.5148	1.7930
190.00	9.34	19.02	40.91	0.02444	157.91	983.9	1141.8	70.7	913.2	1071.1	0.2783	1.5146	1.7929
191.00	9.54	19.43	40.10	0.02493	158.91	983.3	1142.2	70.8	912.5	1071.4	0.2798	1.5113	1.7911
192.00	9.74	19.83	39.31	0.02544	159.91	982.7	1142.6	70.9	911.8	1071.7	0.2813	1.5081	1.7894
192.39	9.80	20.00	39.01	0.02553	160.30	982.5	1142.8	71.0	911.5	1071.8	0.2819	1.5069	1.7888
193.00	9.95	20.27	38.54	0.02595	160.91	982.1	1143.0	71.0	911.1	1072.0	0.2829	1.5048	1.7877
193.22	10.00	20.36	38.38	0.02606	161.10	982.0	1143.1	71.1	910.9	1072.0	0.2832	1.5042	1.7874
194.00	10.17	20.71	37.78	0.02647	161.92	981.5	1143.4	71.1	910.4	1072.3	0.2845	1.5016	1.7861
194.66	10.29	21.00	37.29	0.02682	162.58	981.1	1143.7	71.2	909.8	1072.5	0.2855	1.4995	1.7850
195.00	10.39	21.15	37.04	0.02700	162.92	980.9	1143.8	71.2	909.7	1072.6	0.2860	1.4984	1.7844
196.00	10.61	21.60	36.32	0.02753	163.92	980.3	1144.2	71.3	909.0	1072.9	0.2876	1.4952	1.7828
196.89	10.78	22.00	35.70	0.02801	164.82	979.8	1144.6	71.4	908.4	1073.2	0.2889	1.4924	1.7813
197.00	10.83	22.05	35.62	0.02807	164.93	979.7	1144.6	71.4	908.3	1073.2	0.2891	1.4920	1.7811
197.75	11.00	22.40	35.10	0.02849	165.70	979.2	1144.9	71.4	907.8	1073.4	0.2902	1.4895	1.7797
198.00	11.06	22.52	34.93	0.02863	165.93	979.1	1145.0	71.5	907.6	1073.5	0.2906	1.4888	1.7794
199.00	11.26	22.99	34.26	0.02919	166.94	978.4	1145.4	71.5	906.9	1073.8	0.2921	1.4856	1.7777
199.02	11.27	23.00	34.25	0.02920	166.96	978.4	1145.4	71.6	906.9	1073.8	0.2921	1.4856	1.7777
200.00	11.52	23.47	33.60	0.02976	167.94	977.8	1145.8	71.6	906.2	1074.1	0.2937	1.4824	1.7761
201.00	11.76	23.95	32.96	0.03034	168.94	977.2	1146.2	71.7	905.5	1074.4	0.2952	1.4792	1.7744
201.10	11.76	24.00	32.90	0.03040	169.04	977.2	1146.2	71.7	905.4	1074.5	0.2954	1.4788	1.7742
201.96	12.00	24.43	32.36	0.03090	169.90	976.6	1146.5	71.8	904.8	1074.7	0.2967	1.4760	1.7727
202.00	12.01	24.45	32.33	0.03093	169.95	976.6	1146.6	71.9	904.8	1074.7	0.2967	1.4760	1.7727
203.00	12.26	24.96	31.72	0.03153	170.95	976.0	1146.9	72.0	904.0	1075.0	0.2982	1.4729	1.7711
203.08	12.25	25.00	31.67	0.03158	171.03	975.9	1146.9	72.0	903.9	1075.3	0.2983	1.4727	1.7710
204.00	12.51	25.48	31.12	0.03214	171.96	975.4	1147.3	72.1	903.3	1075.3	0.2997	1.4697	1.7694
205.00	12.77	26.00	30.53	0.03276	172.96	974.7	1147.7	72.1	902.6	1075.6	0.3012	1.4666	1.7678
205.87	13.00	26.47	30.03	0.03330	173.80	974.2	1148.0	72.2	902.0	1075.8	0.3025	1.4639	1.7664
206.00	13.03	26.53	29.95	0.03339	173.97	974.1	1148.1	72.2	901.9	1075.9	0.3027	1.4635	1.7662
206.85	13.23	27.00	29.47	0.03393	174.83	973.6	1148.4	72.3	901.3	1076.1	0.3040	1.4607	1.7647
207.00	13.30	27.08	29.39	0.03402	174.97	973.5	1148.5	72.3	901.2	1076.1	0.3042	1.4603	1.7645
208.00	13.57	27.63	28.85	0.03466	175.98	982.9	1148.9	72.4	900.4	1076.4	0.3057	1.4572	1.7629
208.66	13.72	28.00	28.50	0.03509	176.64	972.4	1149.0	72.5	899.9	1076.6	0.3061	1.4558	1.7619
209.00	13.85	28.19	28.32	0.03531	176.98	982.2	1149.2	72.5	899.7	1076.7	0.3072	1.4541	1.7613
209.55	14.00	28.50	28.02	0.03569	177.50	971.9	1149.4	72.6	899.3	1076.8	0.3081	1.4523	1.7604
210.00	14.13	28.76	27.80	0.03597	177.99	971.6	1149.6	72.6	899.0	1076.9	0.3087	1.4510	1.7597
210.42	14.21	29.00	27.59	0.03625	178.58	971.2	1149.8	72.7	898.7	1077.0	0.3094	1.4496	1.7590
211.00	14.41	29.33	27.29	0.03664	178.99	971.0	1150.0	72.8	898.3	1077.2	0.3103	1.4478	1.7581
212.00	14.70	29.92	26.79	0.03732	180.00	970.4	1150.4	72.8	897.6	1077.5	0.3118	1.4447	1.7565
212.13	14.70	30.00	26.73	0.03811	180.13	970.3	1150.4	72.8	896.7	1077.8	0.3120	1.4443	1.7563
213.00	14.99	30.52	26.30	0.03802	181.0	969.7	1150.7	72.9	896.8	1077.8	0.3133	1.4416	1.7549
213.03	15.00	30.54	26.27	0.03806	181.0	969.7	1150.7	72.9	896.8	1077.8	0.3133	1.4416	1.7549

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

MANAGEMENT OF ELECTRIC STATIONS—II

1332. *Is electric-station work a dangerous occupation on account of the possibility of receiving shocks?*

It is dangerous work for careless men, especially where the current is generated at high voltage. Because a wire or bus-bar carrying current appears the same as it would were it not carrying current, the workers must rely entirely upon their knowledge of the circuit conditions. Ordinarily, it is not difficult to trace out a circuit before working upon it, to determine whether it is connected to a live source.

1333. *Is the human body a good conductor of electricity?*

It is a poor conductor; under the most favorable conditions it offers a resistance of about 2500 ohms. This is the resistance of 300 miles of ordinary telegraph wire. The chief resistance is that of the skin which, when dry, is about 100,000 ohms.

1334. *What voltage is considered fatal?*

Less than one ampere (about 0.8 ampere) of current flowing through the body will produce death, although less than this is often fatal. With the resistance of the body equal to 2500 ohms, the voltage corresponding to the fatal current is, according to Ohm's law,

$$0.8 \times 2500 = 2000 \text{ volts}$$

However, people are frequently killed by much less than this.

1335. *What voltage is considered dangerous?*

As before stated, the skin of the body offers a high resistance and this is particularly true of the hardened skin about the hands, where accidental contact is usually made. Because of this, shocks from pressures below 200 volts need be avoided only on account of the unpleasant sensations. With pressures above 200 volts, care should be exercised to guard against accidents and particularly so in the case of alternating current.

1336. *Have not persons lived after receiving* 100,000 *volts or more?*

Yes; voltages as high as 100,000, which are confined to alternating currents of high frequency, often produce what is known as a "skin effect," that is, the currents do not penetrate the body to any extent but pass over its surface. Therefore very high voltages are less frequently fatal than moderately high ones.

1337. *What is the best safeguard against dangerous or fatal shocks?*

The best safeguard is to make all connections before the current is passed through the circuit. This may be accomplished by introducing a switch in series with each of the main supply wires and the rest of the circuit; and leaving these main switches open until all the other connections are made.

1338. *If the safeguard just mentioned is not practicable, what are the next best precautions?*

When working on live circuits, never place the body so that it can come in series with the circuit or in contact with a part of the circuit at a potential different from that of the wire being held. To prevent this, stand on a dry piece of wood or other insulator and work with one hand as much as possible, keeping the other on some insulating support or in the pocket.

In the case of alternating currents having pressures above 1000 volts, too much care cannot be taken as the leakage is often sufficient to cause a dangerous shock, even though direct contact is not made with the charged parts. Insulated wire often fails to give protection, and it should not be touched unless one stands on a well insulated support and wears rubber gloves, rubber shoes, or both. It is always well to use tools having insulated handles.

1339. *What are the chances of successfully reviving victims of electrical shocks?*

Prompt and continued efforts along the proper lines have proved successful. In order that the task may not be undertaken in a half-hearted manner, it is well to bear in mind that accidental shocks seldom result in death unless the victim is left unaided for too long a time, or efforts at reviving are stopped too soon. In the majority of instances, owing to short and imperfect contact with the conductors, the shock merely temporarily paralyzes the nerves controlling the muscles of respiration.

1340. *What should first be done to revive a victim of electrical shock?*

The body must be removed at once from the circuit by breaking contact with the conductors. This may be done by using a dry stick of wood with which to roll the body over to one side, or to brush away the live wire. In the absence of a stick any dry piece of clothing may be used in seizing the victim. If in contact with the earth, the coat tails of the victim, or any loose piece of clothing may be seized to draw the body away from the conductors.

1341. *After the body has been removed from the circuit, what should be done?*

There are two methods in use for resuscitating the victim; the older and more generally known is the Silvester method. In this the body must be turned upon the back, the collar and clothing about the neck loosened and a coat rolled up and placed under the shoulders, so as to throw the head back. It is also well to feel in the victim's mouth and remove any foreign body, such as tobacco, false teeth, etc. Having done this, efforts should be made to force the victim to breathe, just as would be done in a case of drowning.

To accomplish this, the operator should kneel at the victim's head, facing him, as in Fig. 431, and seizing both arms, draw

FIG. 431

them to their full length over the head, holding them there for two or three seconds only. This is to expand the chest and allow air to enter the lungs. Then the operator should carry the arms down to the sides and front, firmly pressing them on the walls of the chest, as in Fig. 432, thus driving the air out of the lungs.

FIG. 432

1342. *How often should this arm movement be repeated?*

At least sixteen times per minute for an hour or more, or until natural respiration is established.

1343. *Can anything further be done to revive the victim?*

It is advisable to grasp the tongue with a handkerchief or piece of cloth, to prevent its slipping, and draw it forcibly out when the arms are being extended above

the head, as in Fig. 431, allowing it to recede again when the chest is being compressed.

1344. *What is the purpose of the tongue movement?*

It frees the throat so as to permit air to enter the lungs, and also, by irritation from contact of the under part of the tongue against the lower teeth, it often causes an involuntary effort to breathe.

1345. *What other method may be employed to resuscitate the victim?*

The Schaefer or "prone pressure" method has recently been recommended by a joint committee of the American Medical Association, the American Institute of Electrical Engineers and the National Electric Light Association.*

In this the subject, after being freed from contact with the conductor, is immediately placed upon his abdomen, as in Fig. 433, and pressure is applied rhythmically on the loins and lower ribs. To facilitate this the operator kneels,

FIG. 433

straddling the victim's thighs and rests his palms upon the latter's loins with the fingers spread over the lower ribs. With the arms held straight he swings forward slowly (Fig. 434) so that the weight of his body is gradually brought to bear upon the victim. This should take from two to three seconds and tends to com-

FIG. 434

press the abdomen, raise the diaphragm and drive out air from the lungs.

Next, he swings back so as to relieve the pressure and the lungs take in air. This should be repeated 12 to 15 times a minute until natural breathing has been started and then send for a physician.

1346. *Is the latter method better than the first?*

It has the advantage of being simpler and it is free from the trouble caused by the tongue falling back and blocking the air passages.

1347. *Would stimulants help in reviving the victim?*

They would have to be poured down the victim's throat and this would temporarily interfere with his breathing; hence they should not be given until the subject is fully conscious.

1348. *Who is responsible for the supervision and control of an electrical station?*

The superintendent or manager.

1349. *What qualifications must a station employee possess in order to succeed as the superintendent or manager?*

He must have an intimate knowledge of local conditions and requirements, have practical experience in the running of generators, motors, transformers, etc., and understand their principles of operation. He must also possess executive and business ability and have strict integrity.

1350. *What is one of the first problems that often confronts the new superintendent?*

He is frequently given an electrical station equipped with old apparatus and machinery and is confronted with the problem of increasing the net earnings without making any radical changes in the equipment.

1351. *How can he best accomplish this?*

Inasmuch as thousands of dollars have probably been invested in the installation, it is usually impracticable to scrap the old apparatus and machinery at the start and purchase an entirely new equipment. The new superintendent should therefore be content temporarily with the existing apparatus, but he should investigate the situation thoroughly so that when money is available he will be able to make the most necessary additions and improvements to the plant.

1352. *What rules should serve as a guide in making the additions and improvements?*

Make the station conform to modern practice so as to reduce as much as possible the cost of production.

1353. *How should the recommendations be put before the directors?*

They should be formed into a clear statement, covering the best kind of apparatus to install, the cost, and the probable profit resulting through their installation.

1354. *If the suggestions are approved, and, when put into effect, result in an increase of business, what should be the next move?*

The money resulting from the increased business should be applied to further alterations and extensions of the plant. Gradually, the transformation of the station will thus be brought about, and when satisfactory conditions are once secured, every effort should be made toward the maintenance.

1355. *What are the best methods of obtaining good men and retaining their services?*

Showing appreciation of their work by paying them what they are worth and advancing them to higher positions when vacancies occur or new situations open up.

1356. *How should the superintendent be governed in issuing orders to his subordinates?*

The orders must be worded plainly and should be of such a nature that they may be enforced to the letter. Under no conditions must favoritism be shown, and social or political influence should not be considered in the proper enforcement of the orders and regulations of the station.

1357. *What amount of technical training should a man have in order to become a competent station superintendent?*

He should preferably have three or four years' study and experimental work in electrical engineering at a technical school. If he has a persistent, studious nature and is naturally inclined toward the subject, he may obtain the theoretical training by home study.

1358. *What amount of practical training should a man have to become a competent station superintendent?*

The technical training should be supplemented with several years' practical training. A number of our large electrical manufacturing concerns have also regular channels through which one possessing a technical education and being fortunate enough to enter, can secure much valuable experience in the design, construction, testing and operation of the various classes of electrical machines.

1359. *How is the actual worth of a station superintendent to his company usually judged?*

From a profit-making basis.

1360. *Give some general rules for increasing the net profits.*

Reduce the operation and maintenance expenses to a minimum. After reducing the former to a kilowatt-hour basis compare them with corresponding expenses in similar stations, and determine in which direction efforts should be made toward reduction. To reduce the cost of maintenance, have frequent inspections made of all machines and appliances, and whenever a defect is first noted have it attended to at once.

1361. *What privileges should be given the station superintendent by his employers?*

Inasmuch as the superintendent is held directly responsible for the results, he should be given the privilege of putting into effect whatever methods he deems advisable. His methods should not be disputed or confidence lost in his ability until positive proof of failure is at hand. In the meanwhile, they should endow him with full power so that his subordinates will regard him as the one man in authority whose orders are not to be questioned.

*The National Electric Light Association has recently got out a pamphlet and chart covering this method, which it intends to circulate largely.

Care and Operation of Transformers*

By W. M. McConahey

Formerly it was customary to ship transformers packed separately from their tanks. When thus shipped it was practically impossible to prevent the insulation from absorbing moisture, even when special methods of packing were resorted to. Such schemes as packing in tin-lined cases or placing calcium-chloride inside of packing cases never proved very satisfactory, so that before putting a transformer into service it was nearly always necessary to dry it out. This required time and care and a certain degree of expert knowledge which made it very desirable that some method of shipment be devised which would make drying out before installing unnecessary. This is now accomplished by bracing the transformer securely in its tank, filling the tank with oil and shipping in this manner. The only limit imposed upon this method is the inability of the railroads to handle very large sizes because of insufficient clearances. This has been overcome to a considerable extent, however, by the use of a special form of car with the floor much lower than that of an ordinary flat car.

When a transformer is shipped in its own tank with the oil it should arrive at its destination with the insulation and oil practically dry and free from moisture. To make sure of this, however, it is best to draw a few samples of oil from the bottom of the tank and test them. The best way to make the test is to use some standard form of testing cup and a variable-ratio testing transformer by means of which the voltage can be raised gradually. The cup is filled with a sample of the oil, the gap is adjusted to a fixed length with a micrometer screw and the voltage is raised until a spark jumps across the gap through the oil. It is customary to set the gap at about 150 mils, and with such a setting good oil will show a breakdown at not less than 30,000 volts. If no means of varying the voltage is at hand, so that it is necessary to use a fixed voltage for making the test, the gap should be set to give 200 volts for every mil of separation and breakdown should not occur at this setting. However, it is not advisable to use a testing voltage below 6600 volts.

It is important for the life of the transformer, particularly if it be of high voltage, that the tank be closed tightly so as entirely to exclude dust and dirt. This is done by packing tightly around all outlet bushings and placing gaskets under the cover, and also under handhole and manhole covers.

After the transformer has been installed and put in operation, it should not be expected to operate continuously without further attention. A periodical inspection should be made about once every six months. This should include a test of a sample of the oil drawn from the bottom of the tank and an examination of the interior. If the oil shows the presence of too much moisture, or an inspection shows a deposit of dirt or slime in the transformer, the oil should be drawn off and filtered and dehydrated, and the transformer and the interior of the tank should be thoroughly cleaned with dry clean waste. The ventilating ducts can generally be cleaned by squirting dry oil through them. If the transformer is water-cooled the cooling coils should be examined to find out whether any deposit has been formed on them by the oil. Some oils will form a coating on the cooling coils which acts as a heat insulator and causes the transformer to run hot. This deposit can be removed only by scraping and rubbing the coils until they are clean.

If the oil in a transformer is in a dirty condition or forms a deposit, it should be filtered, and if it contains moisture, steps should be taken at once to remove this moisture. The filtering process can be performed easily by passing the oil through two or three thicknesses of bolting cloth.

The removal of moisture is not such an easy task. Various makeshift schemes have been tried from time to time but all of them are far from satisfactory. Among these schemes are placing bags of dry lime in the oil, passing hot air through the oil, or heating the oil so as to vaporize the moisture and drive it off. To remove the moisture completely and leave the oil in first-class condition, it should be passd through some standard form of dehydrator. Probably the best form of this class of apparatus is the filter-press type, in which the oil is pumped through several thicknesses of a specially prepared paper. The paper has the faculty of allowing the oil to pass through freely, while at the same time retaining the moisture until it becomes saturated. When the paper approaches saturation it should be removed and replaced by fresh dry paper.

A simple and satisfactory way of keeping the oil clean and dry is to so connect a small dehydrator outfit to a transformer tank that the oil can be pumped from the bottom of the tank through the dehydrator and back again into the tank at the top. The connection at the bottom can be made through the oil valve provided with all transformers. The necessary connections can be made and the dehydrator put into service without in any way interfering with the operation of the transformer.

Assuming that the necessary care is taken to keep the transformer clean and dry, it is equally important that it be not overloaded to such an extent that the insulation is damaged by excessive heating of the coils. Insulation will not stand prolonged heating at a temperature much above 100 deg. C. without permanent injury.

It is practically out of the question to determine the actual temperature of the copper, which is the hottest part, so that about the only guide the operating man has is the temperature of the oil. It is customary for manufacturers to guarantee that the temperature rise of the windings of power transformers at normal load will not exceed 40 deg. C. The standard temperature guarantee for power transformers when operating continuously at 25 per cent. overload is 55 deg. C.

If the windings are well ventilated the maximum temperature will not exceed the average by more than a small amount, but if they are poorly ventilated there may be a wide difference between the maximum and average temperatures. As the load is increased the temperature drop from the copper to the oil increases rapidly, so that for heavy overloads the temperature of the copper is much above that of the oil. For this reason, if it is necessary to put a heavy overload on a transformer for several hours, some judgment must be exercised in trying to determine from the temperature of the oil what is the temperature of the windings. If this temperature (not temperature rise) is allowed to get much beyond 100 deg. C., there is danger of the insulation being permanently injured.

Self-cooling transformers can now be built in sizes up to about 2000 or 3000 kw., depending upon the voltage and frequency. The output for which water-cooled transformers can be built is limited only by the weight and the mechanical dimensions which make handling or transportation difficult. Ordinarily the water rate is ¼ gal. per minute per kilowatt-loss, which gives a temperature rise of 15 deg. C. from the inlet to the outlet of the cooling coil.

Some water will form a deposit on the inside of the cooling coil which will act more or less as a heat insulator, and may in extreme cases close up the coils entirely. The presence of this deposit can be detected by a decreased flow and an increased temperature rise of the water or by an increase in the temperature of the transformer. It can generally be removed by passing a solution of hydrochloric acid through the cooling coils.

A water-cooled transformer should not be operated except for a very short time without the circulation of water through the cooling coils. The transformer will heat up very rapidly and will soon reach a dangerous temperature. It cannot even be operated in this manner for any length of time without load, because the iron loss in itself is sufficient to raise the temperature above the danger point. To guarantee against overheating due to the

*From a paper delivered before the Seattle convention of the National Electric Light Association, June 10-14.

stopping of the flow of water, it is customary to equip water-cooled transformers with alarm contact thermometers, to which alarm bells can be wired to give warning if the temperature should rise too high.

With air-blast transformers about 150 cu.ft. of air per minute is required per kilowatt of loss. The air pressure required varies from about ½ to 1 oz., depending upon the size of the transformer. If the air pressure is shut off from an air-blast transformer it can carry full load for only a few minutes before reaching a dangerous temperature. This will be understood when it is remembered that there is no oil to store heat, and since there is little radiation, practically all the heat generated in the windings has to be stored in the copper. The thermal capacity of copper is very low, and therefore it heats up rapidly.

Starting cold and throwing on full load, with the air blast going, an air-blast transformer will reach steady temperature conditions in about two hours, while an oil-cooled transformer would require probably six to ten times as long. Because of the rapid heating up of the windings, an air-blast transformer cannot safely carry a heavy overload for more than a few minutes. The temperature rise of the windings under normal operation varies approximately in the same ratio as the copper loss.

CORRESPONDENCE

Circuit Breaker Alarm

Considerable trouble was experienced through the circuit-breakers coming out and as there was much noise around the plant the station attendant was often unaware that a breaker had gone out until the telephone rang and someone would inquire what the trouble was with the power. After being called up several times he concluded to attach an alarm, so accordingly wired up a small bell and a couple of dry batteries as per diagram. The circuit-breakers were each on a separate railway circuit and took their current from the same busbar.

The attendant took off the two clips at *A*, between which the arms of the breakers rest when out, and insulated one side by putting a piece of mica between the clip and the body of the breaker. He also drilled out the holes and bushed them, so that one clip was insulated from the other and when the arm of the breaker came out it rested between the two clips and closed the circuit so the bell would ring. As there was only one bell he thought by connecting it as shown in the sketch it would be all right and would ring when either breaker came out.

The first time breaker No. 1 came out the bell rang all right. The attendant pulled the switch below the breaker and then put the breaker in. Before he closed the switch, however, there was a report and smoke began to roll up back of the board. Upon investigation he found that the wire from the left side of No. 2 breaker was burned off at *X*. It developed that when closing the breaker he also closed the circuit, permitting the current from breaker No. 2 to flow through the batteries and out on the line through No. 1 breaker, but as the wire was not large enough to carry the current, it promptly melted. After procuring another bell and connecting the breakers separately he had an alarm on both breakers and they worked all right.

LEON L. POLLARD.

Fairfield, Maine.

Burnt Commutator Bars

In answer to Mr. Kramer's inquiry in the May 21 issue, I would say that burnt spots on the commutator are caused by loose leads, poor connections between brushes and studs, poor contact of the brushes on the commutator and high mica. Although he says the mica is not high, still from his having repeatedly to sandpaper the burnt spots it would appear that the mica is high, although not all over, perhaps. If not due to the causes mentioned, I would suggest that Mr. Kramer try cutting the mica down $\frac{1}{16}$ in., using for the purpose a sharp, narrow chisel.

HERBERT HILL.

Middle Falls, N. Y.

It appears that Mr. Kramer's trouble is caused by a short-circuit or ground due to oil soaking into the mica and carbonizing it or to arcing due to carbon and copper dust. The arc will eat away the mica and pit the bars on the under side, heating them enough to change their color.

I have had practically the same experience with three different machines and in each case found that the discolored bars were grounded. After putting new mica insulation between the bars and also under them the ground disappeared and we had no further trouble with the bars becoming discolored.

WILLIAM T. GARLITZ.

McKees Rocks, Penn.

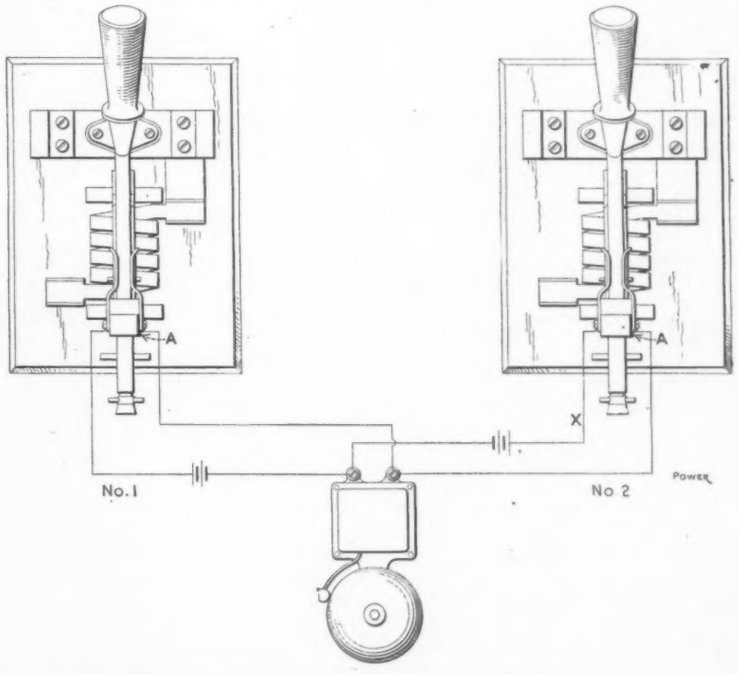
Referring to the inquiry by Mr. Kramer in the May 21 issue, I have a small 125-volt machine which caused considerable trouble by the commutator becoming black and appearing to be burnt. I cleaned it with sandpaper and in five minutes it would be as black as ever. Therefore, I concluded that the brushes had become soft, so put on a new set but without any better results and in three weeks' time they were all gone.

Upon looking over the machine I found the pulley out of round about $\frac{1}{16}$ in. and also a high spot on the commutator about $\frac{1}{32}$ in. I then turned down the commutator and put on a new pulley, also a new set of brushes and have since run the machine 3½ months without a stop. The commutator has not been sandpapered and is as bright as when new. The brushes are also in excellent condition.

I never use any kind of oil on the commutator, but instead use paraffin because it is dry and no dust will collect on the brushes.

G. LAWTON.

Bantam, Conn.



BELL CONNECTED TO BOTH CIRCUIT BREAKERS

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

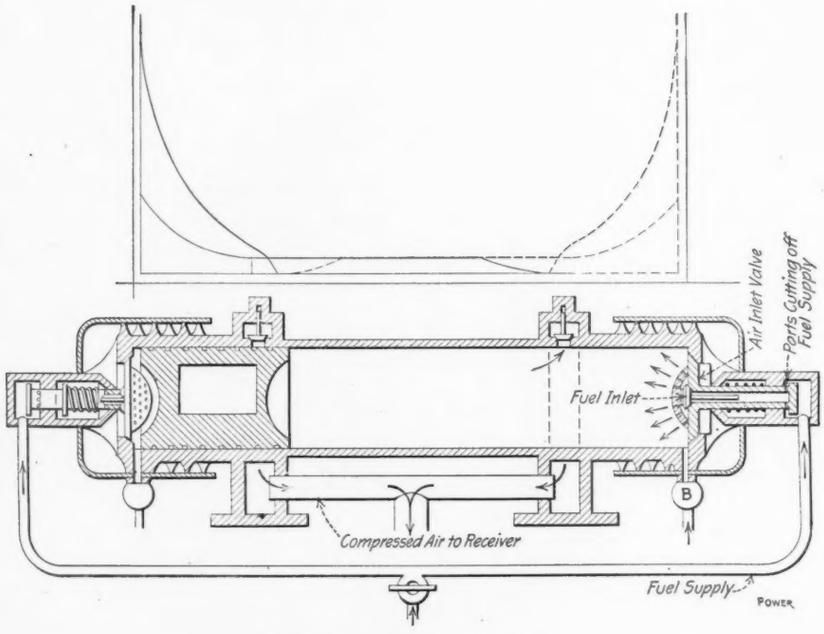
Flying Piston Gas Engine for Air Compression

Among the attempts to make the explosion process of the gas engine act directly (without connection of piston and crank) upon the driven machine, the Humphrey water pump has already reached some practical importance. The idea, therefore, arises whether it is not possible to employ this general principle in air compression, that is, to build a compressor in which the energy produced by combustion of a gas-air mixture shall be used directly for air compression without interposing a crank drive.

In the accompanying illustration, which is reproduced from *Engineering*, is shown such a device ascribed to Guiseppe Matricardi, of Pallanza, Italy. The machine has already been constructed and experimented with. The operation is as follows: A flying piston is driven by the explosion of the gas charge from one end of the cylinder to the other, while its motion compresses the air before it and forces it through a delivery valve into the receiver. The piston must, for such a process, be large enough and of proper weight, its mass being so great that the kinetic energy stored up in it during the expansion of the exploding mixture, suffices to perform the compression work. The air is forced through a passage arranged some distance from the end of the stroke. As soon as the piston has passed over this port, the escape of air is cut off and the air still entrapped in the cylinder, to which the necessary combustible mixture has already been added, is compressed; then occurs the ignition. The piston is then forced back on the return stroke, and the same process is repeated.

The operation can best be followed on an indicator diagram, as shown. At each end of the cylinder is provided an automatic valve through which the air to be compressed enters the cylinder. A cap drawn over each cylinder end compels the air, before entering, to brush the walls for the purpose of cooling them. The spindle of the air inlet valve is hollow and ends in an enlarged chamber. In the cover of this hollow spindle are a large number of fine holes through which the fuel is injected. The injection of the fuel is possible, however, only when the air-inlet valve is closed, since if the valve be open the feed of fuel is cut off. Compressed air is used for starting, the connection being at *B*.

The field of use of such a machine is restricted since it cannot handle pure air, the air delivered being mixed with the products of combustion.



SECTION THROUGH CYLINDER

Operating Features of the Diesel Engine

Much has been printed from time to time in the technical press regarding the design, efficiency and general characteristics of the Diesel engine, but little has been said from the operator's viewpoint. For information of this character we are indebted to William Sowter, who, in a recent paper read before the Dublin Section of the Institution of Electrical Engineers, set forth a number of points gained from several years' experience in the operation of Diesel-engine plants.

He is of the opinion that the life of a Diesel engine is equally as long as that of a well built steam engine, providing, of course, it receives first-class attention. In this respect he points out that a steam plant, if not properly maintained, will become less efficient as time goes on; yet it often continues to run as though everything were in order, but with an increased fuel consumption. On the other hand, a Diesel engine must be kept in good running condition; otherwise there will be difficulty in getting it to run at all and its behavior will at once indicate that something is out of order.

Regarding lubrication, he says, it is important that a pure mineral oil having a high flash point be used; also, in spite of the claim that the cost of lubrication in a Diesel-engine plant is no greater than in a steam plant, his experience has pointed to this item of cost being about 50 per cent. greater in the Diesel plant. However, while efficient lubrication is necessary an excessive quantity of oil should be avoided. The piston and gudgeon pin are lubricated by a pump which forces the oil through a hole in the liner and piston to the pin and also through an annular space between the liner and the cylinder casting. It is the usual practice to have about six small holes through the cylinder at this point and through these the oil is forced to meet the piston. If the oil becomes dirty or contains carbon these holes are liable to become clogged.

Oil from the crank case usually contains carbon and should be pumped into a settling tank, heated by a steam coil or some other means. After settling, the oil should be drawn off from the top and passed through a good filter. It is practically impossible to remove all the carbon from the oil and consequently if the oil is used repeatedly, more and more carbon will be fed into the cylinders and

other parts until sufficient accumulates to completely stop up the passages. For this reason it is recommended that the piston be removed every six months and the lubricating passages cleaned. The carbonization of oil may also cause trouble in the air-compressor cylinders. Before the author realized this possibility, filtered oil was used in the compressor. In the course of time the high-pressure air pipe leading from the compressor to the intercooler blew off at the joint, when it was discovered that the pipe was completely blocked with solid carbon.

On account of the high compression the valves must be kept tight; otherwise leakages will occur, reducing the compression and making it difficult to start the engine; moreover, when started proper combustion will be impeded. Mr. Sowter believes that each valve should be examined and ground at stated intervals. He has found that, under the conditions in which he is working, the valves will run without any attention for the following periods: exhaust, 600 hr.; air, 2000 hr.; fuel, 600 hr., and starting, one year.

The fuel valve is so adjusted that the fuel is sprayed into the cylinder a few degrees before the crank reaches the top center on the compression stroke. It is important that this valve be set properly and be tight; if there is any leakage, fuel will be admitted at the wrong time, resulting in irregular running of the engine. The atomizer is liable to become choked if the fuel is dirty and insufficiently filtered; hence it should be examined and cleaned at the same time as the needle valve.

More or less vapor is carried over into the compressor, and when the compressed air is cooled in the intercooler, this vapor is condensed and unless the drain on the intercooler is blown down frequently, water is carried over into the receivers. This tends to cause rusting which travels from the receivers and pipe to the starting valve where it will accumulate and cause the latter to stick. If this occurs, the contents of the bottle may be lost before the valve can be shut. To avoid this the intercooler drain should be blown down at regular intervals, say every half hour. The air-storage receivers are provided with siphons and drains, and should be drained every day. The high-pressure suction and delivery valves of the compressor require grinding about every 600 running hours and the low-pressure valves about every 2000 hr.

Difficulty in starting is usually due to low compression or incorrect adjustment of the fuel air or exhaust valves. Low compression generally results from a bad condition of the valves and is an indication that they require grinding. Furthermore, the engine may be overheated, due to defective water circulation or overloading, and the valve casings may be distorted, resulting in leakage. If no leakage is apparent from examination, the indicator will show if the compression is low.

The setting of the needle valve may readily be tested by barring round the engine until the crank is near the firing center; compressed air should then be admitted to the blast pipe, the indicator cock opened, and the engine slowly barred around until air commences to issue from the indicator cock. This is the point at which the fuel valve commences to open, and should correspond with the maker's setting marks. The air and exhaust valves should commence to open at the proper time and in order to insure this, most makers stamp on the engine the proper clearance between the cams and rollers at a marked point; these clearances should be checked periodically, and adjusted if necessary.

The exhaust from a Diesel engine should be smokeless, although black smoke may be emitted if the blast pressure is too low, or if the engine is overloaded. The exhaust gases escape at a pressure of about 40 lb. per square inch and a proper form of muffler should be fitted. The author recommended, where possible, to lead the exhaust to the base of an existing chimney.

Regarding cooling water, he contended that the amount required by a Diesel plant is much less than that required by a suction-gas producer or steam plant. His experience had indicated that, with an inlet temperature of 50 deg. F. and an outlet temperature of 140 deg. F., about 3 gal. per brake horsepower are required per hour.

CORRESPONDENCE

Operating with Dirty Gas

We used natural gas for many years and at its failure installed a bituminous producer plant rated at 2000 hp. for power and furnace work. It was claimed that the gas would be free from tar to an extent that no trouble would be experienced from this source. We found it very different, however, for after two hours' run on the manufactured gas the engine had to be shut down to prevent injury to the governor valve.

To relieve conditions a filter (see Fig. 1) was placed on the gas-supply line. The gas enters the filter at the top and the upper layers of filtering material catch most of the tar. These usually have to be changed weekly, although the lower layers will last as long as three weeks if the gas is not too bad. About 8 lb. of waste are required to charge the filter. It would not make much difference whether the gas came in at the top or bottom of the filter; only it permits the removal of the layers which have become so foul as to restrict the flow of gas, without disturbing the remainder.

Once a week the governor valve is removed and cleaned, and every three weeks we clean the gas passages between the governor valve and the cylinders and grind the valves.

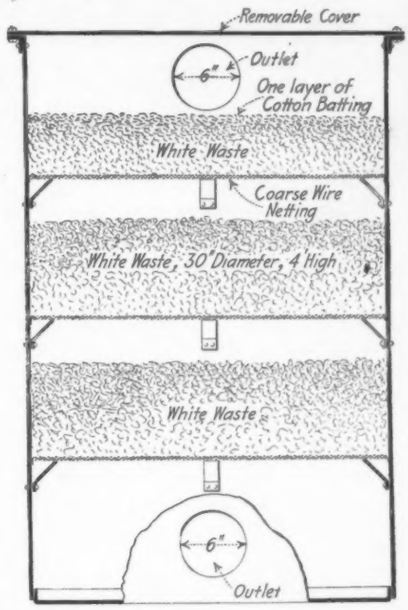


FIG. 1. SECTION THROUGH FILTER

After an engine has been in service some time, ridges will form around the seat and, as the valve stems and the guides become worn, there is a likelihood of the valves seating on these ridges, causing them to leak and affecting the satisfactory operation of the engine.

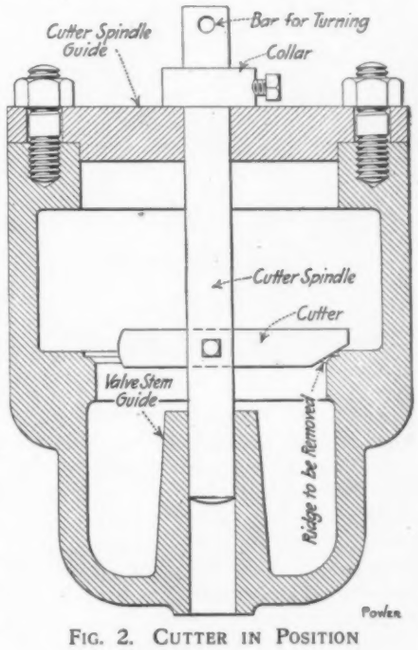


FIG. 2. CUTTER IN POSITION

Fig. 2 represents the tool used in removing the shoulders from the valve seats. The feed is gaged by letting the cutter rest on the ridge, then raising the collar the thickness of a piece of paper.

J. O. BENEFIEL.

Anderson, Ind.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Good Economy in a Gas Power Ice Making Plant

By C. A. Tupper

At Toledo, Ohio, the Citizens' Ice Co. operates an ice-making plant with a capacity of 70 tons of raw water daily. In its design the management was highly successful in securing high operating economy: (1) by the use of natural gas as fuel; (2) by its utilization in the cylinders of a gas engine rather than for raising steam in boilers, and (3) by reducing the distillation of water to a minimum.

The ice machine installed is of the "Great Lakes" design, having two vertical single-acting ammonia compressors, with 18x30-in. cylinders. The ammonia condenser is of the double-pipe style, having eleven 1¼- and 2-in. pipe coils 12 pipes high, and measuring 19 ft. over all. The ammonia receiver is 24 in. in diameter by 10 ft. long.

The freezing tanks contain the usual 1¼-in. ammonia evaporating coils provided with 696 four hundred-pound cans; the tanks are operated on the flooded system. The accumulator has one ammonia expansion valve; and a coil in contact with the humid suction gas from the tanks on its way to the machine serves to precool it.

Gas power being used for driving the ice machine, there is no exhaust steam available to make the usual distilled water ice, but ice of excellent quality is produced mainly from raw water.

The cans are filled with filtered raw water, and air is introduced into the center of each can through a ¼-in. pipe dropped into the can from the top. Ten cans are handled as a unit; that is, a 1-in. air pipe crosses over the top of each row having 10 branch pipes, one for each can. The air is supplied by a Sturtevant pressure blower driven from the main engine.

Before the ice block is entirely congealed or when there still remains a hole several inches wide, the air pipe is withdrawn; and the water, with the impurities forced out by freezing, is eliminated by introducing a piece of pipe connected to a suction pump. The center of the block is then filled with distilled water. The ice block thus obtained is a raw-water block with distilled-water core.

The ice machine is driven from a 300-hp. Allis-Chalmers horizontal tandem, four-cylinder, double-acting gas engine, 18x24 in., running on natural gas.

The gas and air are controlled separately by throttling valves located in each cylinder. This permits varying the compression to suit different loads. The main inlet valve is of the single-beat poppet type, eccentric operated. The gas valve is in one piece with the main valve and opens somewhat later than the latter, to insure scavenging the cylinder before the mixture is admitted. The exhaust gear is similar to the main inlet gear and is operated through a series of rolling levers from the main eccentric. All exhaust is muffled.

The engine produces its own electric igniting current, a small generator being belted from the main shaft.

For starting the engine, air is stored in tanks at 200 lb. pressure by a small belted compressor driven from the engine. The starting device consists of a small poppet inlet air valve at each end of each cylinder, operated by the layshaft. Air is admitted to each cylinder in turn at what would be the working stroke.

All wearing surfaces, including the main bearings, slides, crank and crosshead pins, are arranged for a continuous gravity and forced-feed oiling system, and the cylinders are lubricated by Richardson sight-feed oil pumps. The cylinders and exhaust valves are water-jacketed, and the piston rod and piston are hollow and water cooled. The consumption of gas was smaller than anticipated, but more water was used for cooling than expected.

To further increase the economy of the plant beyond that gained by using

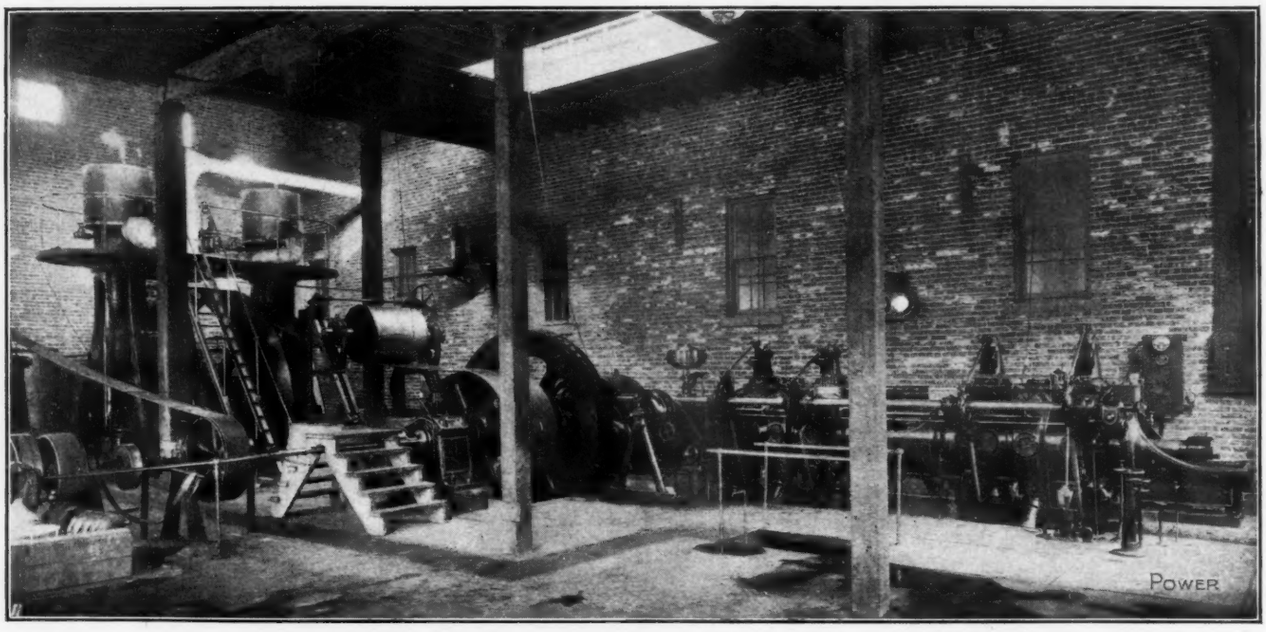


Fig. 1. Ice Making Plant of Citizens Ice Co., Toledo, O.

raw water and gas power, the distilled water for the cores is furnished by Griscom-Spencer multiple-effect evaporators. These produce several times the weight in distillate of each pound of steam supplied to them. The steam is furnished by a 20-hp. Erie City return-tubular boiler, fired by natural gas.

Two air-hoist ice cranes remove the ice to the dumps, air being furnished by the belted compressor mentioned, which was made by the Union Steam Pump Co.

The Downie water-circulating pump is a double-acting deep-well pump. The well, about 600 ft. deep, supplies an abundance of water at 53 deg. F.

The ice machine is belt-connected to the gas engine without any clutch. Full-size bypass connections on the ice machine enable the engineer to start the gas engine without load. The auxiliaries, including the water pump, pressure blower and air compressor, are driven from a line shaft belted to the shaft of the gas engine and operated through a clutch coupling. Should the gas engine be shut down for any reason, this clutch coupling is disengaged and the auxiliaries are driven by a 25-hp. motor, taking its current from the mains of the local electric company.

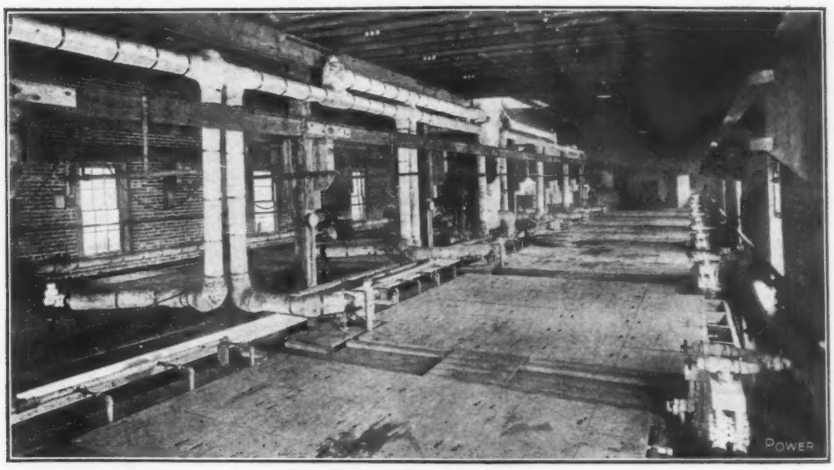


FIG. 2. FREEZING TANKS WHICH ARE OPERATED ON THE FLOODED SYSTEM

The machinery was shut down from October, 1911, until March, 1912, without overhauling, and J. M. Murphy, secretary and general manager of the company, to whom the writer is indebted for these data, states that when started up it ran perfectly.

Sweating Causes Disintegration of Pipe Covering

In the plant of a correspondent, the sweating of a refrigerating pipe has caused the partial disintegration of the 3-in. cork covering. He inquires whether wrought-iron pipe painted or galvanized pipe will remedy the trouble. The answer may perhaps be of general interest.

Unless the pipe has actually rusted through, the moisture encountered does not come from the inside; there is no such thing as sweating through a pipe. The so called sweating of cold surfaces is due to the cooling of the surrounding air by contact with the cold surface.

Air always contains a certain amount of latent humidity; in other words, there is always mixed with air a certain amount of water vapor. The capacity of the air to carry this vapor depends directly on the temperature. The warmer the air the more vapor it will hold, the colder the less. When air is saturated with vapor—that is, when it has absorbed all the vapor it can at a given temperature—the slightest drop in temperature will produce precipitation or a throwing down of a part of the moisture. If the temperature, on the other hand, rises, the air will no longer be saturated and a capacity for absorbing more moisture will have been created.

The temperature at which air becomes saturated is known as the "dew-point." When drops of water appear on a cold brine pipe or even a pitcher of ice water, it is because the layer of air immediately surrounding the cold surface has been chilled below the dew-point and a part of the moisture has no longer been able to remain in the air. In the case of a cold pipe insulated with cork or other kinds of covering, the liability of the air to be cooled to the dew-point is greatly reduced since the temperature of the outside of the covering is not nearly so low as that of the pipe.

Nevertheless, a condition of atmospheric humidity will sooner or later exist when contact with a surface only a degree or two colder than the air will produce precipitation. If there is even the smallest opening through the waterproofing on the outside of the covering, air will enter, and since the farther it passes into the covering the lower the temperature encountered, the more likelihood of precipitation. When the moisture has once been precipitated in the small openings through the waterproofing it has limited exposure to the air for reëvaporation, and unless there is a rise in temperature to increase the absorptive power of the immediately surrounding atmosphere it will remain there.

If the temperature of the insulation finally falls below 32 deg., the moisture is frozen and in so doing expands, cracking the insulation still further, and into these minute cracks the moisture flows when a successive rise in temperature melts the ice. A re-occurrence of the freezing operation still further tends toward the decomposition of the insulation and the nearer the moisture penetrates to the low-temperature pipe and the more frequent the variations in temperature, the more rapid will be the deterioration.

The place for the waterproofing or, more accurately, air-proofing of all kinds of cold insulation, is where it comes in contact with the air, and not at a place remote from the point of attack as in the case of the application of waterproof paper, paint, etc., next to the surface of cold pipes. The only possible function of such waterproofing would be to prevent the pipe from rusting after the insulation has been penetrated and rendered useless by moisture.

If the present pipe covering is badly disintegrated and shows signs of being frozen, it should be removed and replaced by a new covering. If it only shows deterioration in places, it can possibly be dried out. If there is any time of year when the pipes are not in service for a considerable length of time, they may be disconnected and the drying operation accomplished by passing steam through them. When the insulation has been thoroughly dried the exterior should be given a good coat of rubber sealing compound, supplied by the manufacturers, or several coats of paint.

Charging Ammonia into Compression System

The mechanical details of different compression refrigerating plants vary somewhat so that the accompanying diagram is only a sketch of the system. The ammonia liquefied in the condenser flows to the liquid receiver in all compression systems. From the receiver the liquid flows through a stop valve *S* to the neighborhood of the cold-storage compartment to be refrigerated or to the ice-making tank, as the case may be, where it passes through an expansion valve *E* into the expansion coils.

Somewhere between the valves *S* and *E* or the stop valve on the receiver and the expansion valve on the expansion coils, is usually located an outlet closed by a charging valve *C* to which the ship-

ping drums of ammonia charged into the system are attached. The procedure is as follows:

The shipping drum *SD*, full of ammonia, is placed in a convenient position near the outlet *C*, the valve end of the drum resting on the floor, the other end being elevated on a block 4 or 5 in. high. Connection between the valve on the drum and the charging valve can best be made through a flexible pipe connection made up with four ells and a box union something like that shown in the sketch; this connection will allow the position of the charging drum to be shifted slightly. Connection having been made, the stop valve on the charging drum may be slightly opened to allow sufficient ammonia to pass out into the connecting piping to test it for leaks.

If the piping is found to be tight, the valve *S* on the receiver can be closed and the valve *C* opened, in which case, providing the stop valve on the tank is wide open, valve *C* will act as an expansion valve. The liquid ammonia from the shipping drum is forced up hill into the system because of the pressure of the ammonia vapor in the shipping drum above the liquid.

Water from the bottom of a boiler under pressure would be forced up hill in the same way because of the pressure of the steam above the water, the only difference being that whereas it requires the high temperature of the firebox to raise steam pressure, ordinary atmospheric temperatures are sufficient to keep up the pressure in vessels containing anhydrous ammonia.

As soon as the liquid has been exhausted so that there is no longer sufficient evaporation to maintain a high pressure in the drum, the temperature of the remaining liquid ammonia drops with the decreasing pressure until at 47 lb. the temperature of the liquid reaches 32 deg., which is sufficiently low to precipitate and freeze moisture from the atmosphere. This appears as frost on the outside of the charging pipe.

The disappearance of this frost indicates that no cold liquid is passing or that the drum is empty. After closing the drum stop valve and valve *C*, the piping can be disconnected and another drum substituted.

If care is exercised in regulating the expansion through valve *C*, the operation of the machine need not be interfered with except in case of machines so large that the expansion of the ammonia from a single drum will not maintain the accustomed back pressure, in which case the machine should be slowed down until the charging process is completed.

CORRESPONDENCE

Boil-over in Absorption Machine

Boil-overs are more prevalent with vertical than with horizontal generators. The action is very similar to that of priming in boilers. The aqua in the generator suddenly disappears, passing into the condenser and filling the receiver. The extra amount of heat brought into the condenser by the hot aqua will heat the water in the condenser and thus hold up the head pressure; very often it will raise the pressure. This puts the machine out of commission as far as freezing is concerned.

When a boil-over occurs, it is best to cut the steam off of the generator, and leave it so, as long as the head pressure is great enough to drive liquor from the generator to the absorber. Plenty of cooling water should be used on the absorber and the foul gas burnt off; in other words, proceed at once to get a vacuum on the low-pressure side of the machine. The expansion valve, or dump if there is one on the machine, should be opened and thus let the liquid in the receiver work its way back to the absorber. This may take some time and often requires a high vacuum on the absorber. As soon as the liquid begins to show in the absorber gage-glass, turn a little steam on the generator and start the ammonia pump. It is well to start the machine very slowly and be careful that the condenser and dehydrator are not too cold. It may be necessary to turn off the cooling water until the machine is well started.

The fundamental cause of a boil-over is a sudden reducing of pressure in some part of the high-pressure side outside of the generator. This can happen in several ways. High water in the boilers giving wet steam reduces the amount of gas generated, thus lessening the quantity of the gas to the condenser, so that its temperature drops and likewise the pressure. This reduction in pressure does not show on the high-pressure gage, since the gage is attached to the generator. The same condition is brought about when the steam trap on the generator fails to work continuously. Very often the dehydrator will get too cold and act as a condenser, bringing about a reduction of pressure in the condenser, as in the previous cases. The above conditions are more apt to occur, where the aqua is weak or very dirty (soapy).

If the operator will be careful to regulate the steam to the generator, cooling water to the condenser and dehydrator, the expansion valve, and the speed of the ammonia pump, all to suit the load required of the machine, there will be very little trouble from boil-overs.

GAY A. ROBERTSON.

Louisville, Ky.

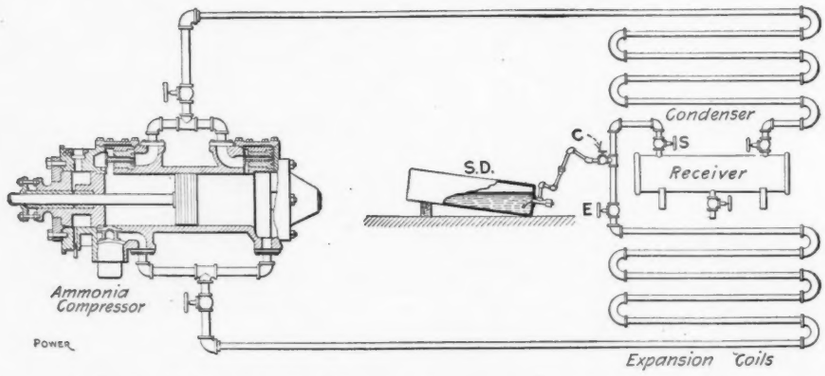


DIAGRAM OF COMPRESSION SYSTEM, SHOWING CHARGING CONNECTIONS

Summer Course in Refrigeration

Of special interest to refrigeration engineers and students of mechanical refrigeration is the summer session of the College of Mechanics and Engineering of the University of Wisconsin.

The school opened June 22 and includes the study of heat engines, gas producers, power plants, refrigerating machinery, principles and methods of producing low temperatures, etc. It closes Aug. 30. Full information is given in a bulletin issued by the university and obtainable by addressing F. E. Turneaure, dean of the College of Engineering, University of Wisconsin, Madison, Wis.

Running a plant along the line of least attention means least pay for the engineer.—*Modern Engineer.*

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT
Of this issue, 29,500 copies are printed. None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

	Page
New San Joaquin Power Plant	74
An Old Mine Pump	76
A Modified Orsat Apparatus	77
Standard Flanges and Flanged Fittings	78
Effect of Pressure on Water Rate of Steam Turbine	79
Method for Filing Literature	79
Low Pressure Steam Tables	80
Catechism of Electricity	84
Care and Operation of Transformers	86
Circuit Breaker Alarm	87
Burnt Commutator Bars	87
Flying Piston Gas Engine for Air Compression	88
Operating Features of the Diesel Engine	88
Operating with Dirty Gas	89
Good Economy in a Gas Power Ice Making Plant	90
Sweating Causes Disintegration of Pipe Covering	91
Charging Ammonia into Compression System	91
Boil-over in Absorption Machine	92
Summer Course in Refrigeration	92
Editorials	93-94
Readers with Something to Say: Boiler Drops under High Pressure....Cleaning a Flywheel Pit....A Twisted Valve Stem....Repair to a Governor Valve....A Faulty Friction Clutch....A Simple Damper Regulator....Emergency Steam Main Repair....What Broke the Discharge Pipe?	95-96
Questions Before the House: Effect of Stiffness of Head on Braces....Improved Flue Gas Sampler....Calculating Horsepower on the Slide Rule....Turbine or Engine....Breakage of Separator Glasses....Saving the Heat Units....Efficiency of Joints in Boiler Shells	97-99
Inquiries of General Interest	100
Study Questions	101

POWER

Tendencies in American Engineering Practice

As a rule, American engineers bear a reputation for being progressive, in contrast to the ultra-conservatism of the English. While this may apply in general, still one is forced to admit two tendencies prevalent in American practice regarding the adoption of anything new in the power-generation field—either skepticism totally excludes or delays the adoption of really meritorious apparatus, long after it has been in practical use elsewhere, or the enthusiasm for a new thing, highly efficient in itself, carries it into fields for which it is not adapted.

A few years ago the steam turbine attained great popularity, and many predicted that the knell of the reciprocating engine had been sounded; yet for certain classes of service the reciprocating engine is still holding its own. This is not to the detriment of the turbine, which for large units under steady conditions of load and speed, has come to stay, but it merely goes to prove that no type of prime mover, however efficient in itself, is suitable to meet all conditions of service.

Similarly, not long ago great predictions were made for the producer plant, which many believed would displace the steam plant. Upon this wave of popularity many plants of this type were installed under conditions for which they were not adapted. When the expected results failed to materialize, the producer installations were blamed, whereas the blame should have rested upon the engineer who installed the plants and who was not far-sighted enough to analyze and meet the existing conditions.

While the producer plant is thermally more efficient than the steam plant, its initial cost is greater and its life less; also certain local and operating conditions must be considered. Nominally the field for the producer is in the utilization of low-grade coals.

Still another case is that of burning oil fuel under boilers. This is used almost exclusively on the Pacific coast where coal is expensive and oil comparatively cheap, whereas on the Atlantic coast the conditions are just the reverse. In practically all cases the problem is economic and is affected by local conditions; unless worked out on that basis, good results cannot be expected.

Become a Designing Engineer

Should a steam engineer be content to remain confined between the four walls of his engine room, or should he so develop his knowledge and broaden his scope of usefulness that he will be capable of accomplishing more important work than that of starting and stopping his engines? In other words, should he confine his ability to operating a steam plant successfully, or should he fit himself to meet possible demand for extensive alterations, or the building of a new power plant; in fact, become a designing engineer? If not, where is the dividing line between the operating and consulting engineer?

The trouble with most engineers is that they are content to let someone else think for them, plan for them and supervise the carrying out of such plans.

A competent engineer should not hesitate to assume the responsibility of designing a power plant if one is required and he is given the opportunity to do so. It is true he may make mistakes; so do consulting engineers. There might be features about the finished installation open to criticism, but whoever inspected a power plant where some feature could not be improved?

Nothing venture, nothing gain, is a truism. Nothing ever would have been accomplished in the mechanical or scientific worlds, had only those who thoroughly understood the problems worked them out; there would have been no problems.

Take a 1000-hp. plant. Most engineers have a general idea of the equipment that should be installed. Sizing up the general conditions and demands upon the plant will be necessary. The well read

man could draw a general layout of the plant, and knowing the available space, operating conditions and money available could design a station that would meet the requirements and operate economically.

How? By using his eyes, profiting by his own experience and that of others and obtaining data from the operation of other successful plants.

Because it is not the custom for operating engineers to design power plants, it is no reason why he should not begin, broaden out in his work and make himself a more valuable man.

If one makes a practice of visiting power plants he will be surprised, perhaps, to find that many have been designed and erected by the chief engineer. He will find them well laid out, operated efficiently and with credit to the men who had the courage to tackle the larger end of power-plant engineering.

Furthermore, a man who can design a plant is more capable of successfully operating it than the man who is content to start and stop the engine.

Effect of Stiffness of Head on Braces

On page 97 a correspondent takes exception to our editorial in the issue of June 11 upon the above subject.

The instructions given by the Ohio Board of Boiler Rules implied that the ability of the head to withstand pressure is its unbraced capacity *plus* the capacity added by bracing.

An unbraced head will bulge under even a little pressure. The Nichols formula determines the pressure, which allows it to bulge only a permissible amount. Any such amount of bulge would, however, produce an excessive strain in the braces.

The pressure allowable upon an unbraced head by letting it deflect an amount which will not unduly strain the material, and that provided for by holding the head rigidly in place by braces, depend upon incompatible conditions, and the safety of the head can never be proportional to the sum of the two.

The formula given by the board allows an unreasonably small number of braces, as the example given in the editorial criticized shows.

If the rule which these instructions modify imposes excessive bracing, it should not have been adopted. If the bracing which it requires is necessary for safety it should be enforced. If it is advisable to continue in service temporarily, boilers which have not sufficient bracing to comply with this rule, an exception should be frankly made in their cases for the length of time desired, instead of resorting to a subterfuge, which involves a mechanical fallacy.

The Mechanical Engineer

As in other places, the line of succession keeps up in the power plant, and it is a school that, after due service, sends forth its graduates. The man in the chief position has an assistant qualified to succeed him, or steadily becoming so. This way of fitting for promotion is direct in the marine service, and in the stationary branch not markedly indirect.

In the great industrial field there are many vocations, but it is doubtful if any offers a greater incentive for studying and mastering command of the essentials of the calling than that of the mechanical engineer. In a peculiar way it has a prestige of its own; it represents power, and the greater the engineer's fitness, the more substantial are the rewards. If the occupation has risen to the dignity of a profession, the credit belongs to painstaking workers in its ranks.

In his "History of Our Own Times," Justin McCarthy states that Stephenson's locomotive ascended its throne in its great test trial at Ramhall, England, in 1832, a test in which John Ericsson figured with his own outfit. Stephenson won.

Of mechanical achievements, McCarthy remarks the hostile sentiment evinced by a certain influential class against the notice and the honor and rewards in prospect for such toilers as Watt and Stephenson. It was a vulgar intrusion of mere mechanics; it was a surprise from a humble source. But logical events stunned and subdued this class, and began the era of a new profession wherein not the designers of machines alone, but the skillful operator who handles them competently has won an enviable title.

An effort in the direction of supplying technical information to practical men, analogous to that contemplated by the Institute of Operating Engineers, is being made at Alton, Ill., under the inspiration and direction of Wilbur R. Smith. An organization of woodworking machinery operators has been effected and the plan is to organize operators of other machinery, including power-plant engineers, to secure the adoption of an industrial course in the public schools, organize classes, lectures, discussions, etc. The woodworkers are working under the auspices of the Educational Committee of the Y. M. C. A. with a membership of over one hundred and an average attendance at the classes of over fifty.

Know Your Employees

It was once believed that personal contact with his employees detracted from the dignity of the typical old-time manager. The present-day head of a concern knows that by personal contact he can awaken an interest in many of his men who hitherto seemed indifferent to all else but the pay envelope. He realizes that his own position is greatly dependent upon securing the working force's maximum efficiency. If he stands aloof, they show no interest; if he goes among them and shows a personal interest in their comfort and their work, he gets an added output and willing service.

In most industrial organizations the business methods have been reduced to an exact science, the machinery is the last word in efficiency, but the power plant is often treated as a necessary evil and about all that is known of it is that it is a big expense item on the books. One manager said recently that he had not entered the plant for six months. Such inattention discourages the engineer who, under other conditions, would take pride in his work, perform his labors willingly and study his employer's interests.

Once the "absentee" manager shows himself to the engineering force, inquires into its ways of work, is solicitous for its comfort and studies its needs, he will find that if his employees have shown indifference it is due to his own neglect, and that they are treating him just as they have been treated.

It is only natural for men to be stimulated to better endeavor when they can claim to know their employer and say that he knows them and what they are contributing to the success of his business.

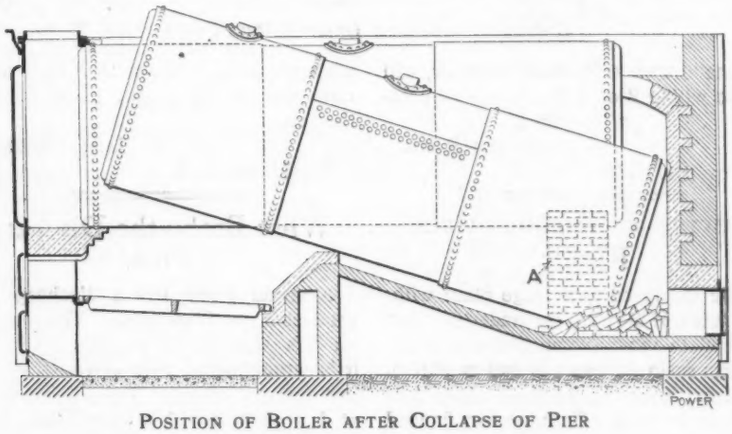
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Boiler Drops under High Pressure

On the morning of June 18, at the plant of the Windsor Print Works, North Adams, Mass., a serious boiler accident occurred to a 60-in. by 15-ft. return-tubular boiler, the setting of which is herewith illustrated. There was no loss of life but the fires had to be drawn in the 20 boilers of the plant, causing interruption of service.

All the boilers are of the return-tubular type, 60 in. by 15 ft., and two shells are supported over one furnace by a wall at the front and a brick pier and saddle at the rear. There are no center walls in the furnaces. The pier *A* supporting one boiler crumbled and fell, allowing the shell to fall on the bridge-wall, as shown in the full lines, or, as the fireman aptly expressed it, "She stood on her hind legs."



POSITION OF BOILER AFTER COLLAPSE OF PIER

Although the "twin" boiler was not disturbed in its setting, many of the steam and water connections were broken. Great excitement prevailed in the boiler room until the steam pressure was reduced and the fires in all boilers drawn.

A. W. GRISWOLD.

Cheshire, Mass.

Cleaning a Flywheel Pit

The following ingenious trick I saw worked by an engineer surprised me with its simplicity.

In our plant it became necessary to clean out a flywheel pit of an engine as it was partly filled with small stones and mud, due to some mason work done around it. The engineer took a stout rope and wound it around part of the rim of the wheel. The rope was put on thick enough to fill the space between the wheel and the bottom of the pit. The wheel was then turned a revolution and all the dirt was thrown out on the engine-room floor. This may be an old kink among power-plant men, but it was a new one to me.

FREDERICK HANSA.

New York City.

A Twisted Valve Stem

One day when making my rounds of the plant, I heard a continuous rattle in the long condenser piping. From previous experience I knew that one of the engines in my charge had broken something, so I started in their direction. When nearly there, one of the oilers notified me that something was wrong with his engine. The engine was revolving at about half speed under the load and steam was blowing through the low-pressure cylinder. The engine was shut down immediately and we started to investigate.

I first took the head off the high-pressure cylinder, thinking that possibly some of the follower bolts had become detached and got into the low-pressure cylinder, but the high-pressure piston was in good condition. The low-pressure cylinder head was also taken off and everything in the cylinder was found all right. All the snap rings were examined and showed no damage. I next took off the caps of the valves and discovered that the admission valve on the low-pressure cylinder had evidently got a bump which twisted the stem. The valve was far enough away so that the piston could not have done it, and the only conclusion I could come to was that at some previous time this engine had been wrecked and the broken parts had remained in the receiver or piping, and at this particular moment had got into the low-pressure admission valve, twisting the stem.

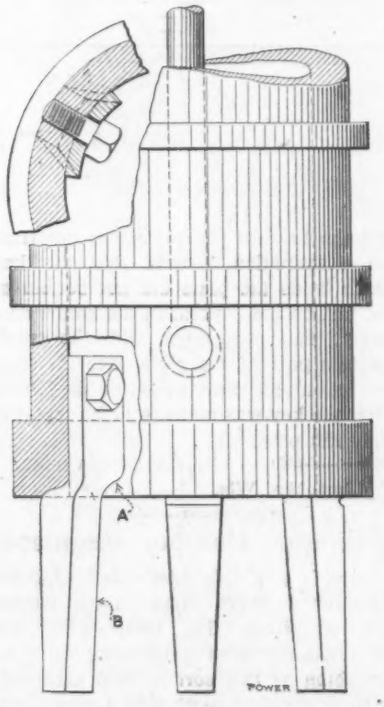
Fortunately I had a spare stem so I put it in place, set the valve and then took it down and cut a keyseat in it. This all took time, however, and it meant a six-hour shutdown before we got started again.

A. RAUCH.

Pittsburgh, Penn.

Repair to a Governor Valve

The valve of our engine governor lost one of its legs, which prevented it from sliding freely in the bore of the valve chamber. Because of this and the valve being worn, it was apt to fall a little to one side and bind against the chamber. Although it would throttle the steam and regulate the speed satisfactorily, I decided to avoid trouble by repairing the valve.



SHOWING NEW LEG ATTACHED TO GOVERNOR VALVE

It was a cast-iron valve, as shown, and I remedied the fault by making and attaching a new leg. It happened that the leg broke off flush with the valve, so I filed it smooth and from a piece of ⅜-in. square iron made a new leg. Where

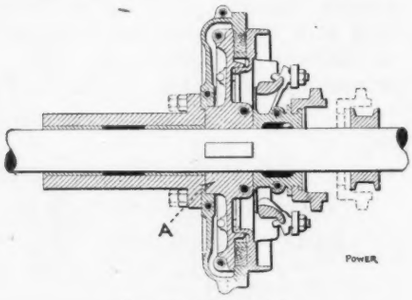
the new leg had to go, I filed a small slot *A* and into it the leg was fitted. The top of the leg, where it was fastened to the valve, was heated and drawn to give more surface as I wished to fasten it with a ⅜-in. bolt. The shape of the leg is shown at *B*. There was ample room for the head of the bolt in the recess of the valve, and it did not interfere with the action of the governor spindle. After the bolt was screwed in tight, I upset the end of it to prevent it from coming loose. The leg was filed a true circle with the opposite one and the job proved very satisfactory.

H. W. HANKIN.

Troy, N. Y.

A Faulty Friction Clutch

Recently I erected a large friction clutch upon a 3 7/16-in. shaft. But upon running the clutch I found that the stationary friction or driving plate *A*, shown in the illustration, did not run true with the shaft. I was under the impression



FRICTION CLUTCH

that the base of the plate was not true, but examination showed that the key which holds the plate did not bottom at one end on the keyseat in the shaft, thus leaving that point high, with the result that the part of the plate with the keyseat could not seat solid on the shaft. After the key was made to fit its seat, the plate ran true.

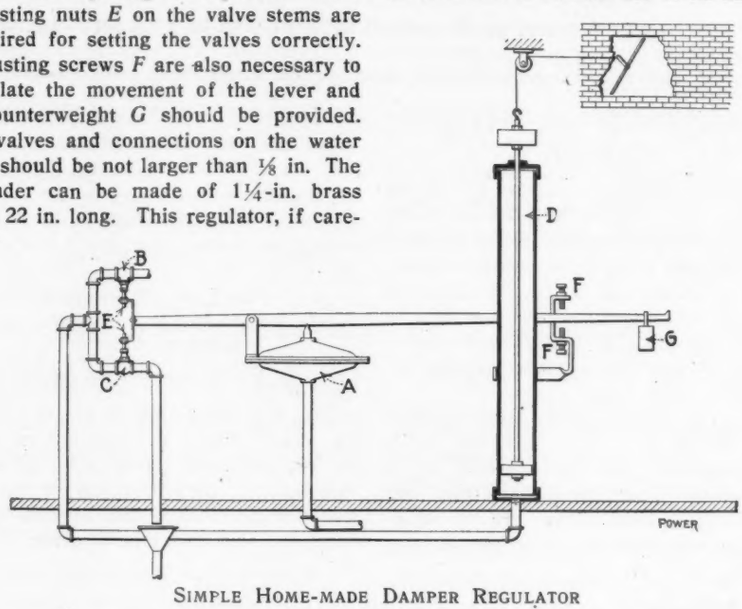
H. A. JAHNKE.

Milwaukee, Wis.

A Simple Damper Regulator

Here is a simple home-made damper regulator I made from things mostly gathered from the scrap pile. An old diaphragm from a reducing valve or something of that sort is most essential. Connect the diaphragm *A* to a steam line from the boiler. Procure two ⅛-in. globe valves and file off the threads so they will work easily, and connect as shown. As the steam pressure rises, the valve *B* opens, and valve *C* closes. Water is then admitted to the cylinder, raising the piston, which is connected to the damper by a cord, and closing the damper. As the pressure lowers, the lever drops, closing valve *B* and opens *C*, draining the cylinder *D*, allowing the weighted piston to open the damper. The valves should be connected so that the water pressure is on top of the disk, for then the lever will act much more quickly.

At 60 lb. water pressure, or over, a very small opening is required. Small adjusting nuts *E* on the valve stems are required for setting the valves correctly. Adjusting screws *F* are also necessary to regulate the movement of the lever and a counterweight *G* should be provided. All valves and connections on the water line should be not larger than ⅛ in. The cylinder can be made of 1¼-in. brass pipe 22 in. long. This regulator, if carefully made with knife-edge bearings, will operate within 2 or 3 lb. change of pressure.



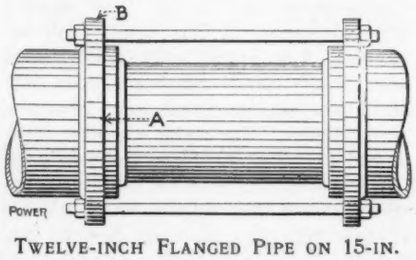
SIMPLE HOME-MADE DAMPER REGULATOR

WILSON RACE.

Jamesville, N. Y.

Emergency Steam Main Repair

While employed at a large plant within 50 miles of Boston, we undertook one week-end to renew some parts of a 15-in. steam main that was in bad condition. The measurements had been taken and new parts ordered. The pipe was flanged and we did not discover until we had



TWELVE-INCH FLANGED PIPE ON 15-IN. STEAM LINE

hoisted the pipe into place that one of the pieces was 2 ft. 2 in. short and another about 2 ft. 6 in. short. Here was a serious condition of affairs, and the nearest place to get pipe of this size was nearly 50 miles away. The telephone was kept busy for about half an hour with the result that we found we could not get a filling-in piece before Monday night, but that at a place about five miles away we could get 12-in. pipe the next morning, which was Sunday.

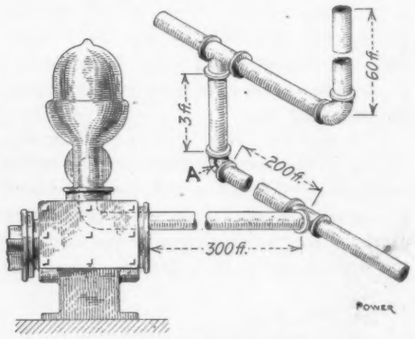
We finally got around the difficulty by making the connection illustrated. A 12-in. flange *A* just fitted inside the bolt holes of the 15-in. flange *B*, so by taking short pieces of 12-in. pipe with a flange on each end, using ⅞-in. rods with a nut on each end to connect the 15-in. flanges, we were able to start on time and run until we got the proper pieces to finish the job.

JAMES ROONEY.

Providence, R. I.

What Broke the Discharge Pipe?

A steam pump has a discharge pipe connected as illustrated. The pressure on this pipe never exceeds 40 lb. and it is wrought-iron with extra-heavy cast-iron screwed fittings. Twice it has broken at *A*, each time with a clean break, showing no flaws in the fitting. The pump



LAYOUT OF DISCHARGE PIPING

makes only 40 strokes per minute and there is no air to cause water-hammer. I know that it would be better if the 60-ft. riser went directly up instead of having the tee connected "bullhead," as shown, but, although this connection is wrong, I do not think it is the cause of the break. Perhaps some interested reader can suggest the real cause.

JOHN STRONG.

London Junction, Ont.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Effect of Stiffness of Head on Braces

In an editorial under this heading in the June 11 issue, the Ohio Board of Boiler Rules is rather severely criticized as to its ruling relating to strength of flat heads. The Board is under no misapprehension as to the strength of flat surfaces and the writer of the editorial would have been fairer if he had stated the conditions under which the instructions quoted were issued.

Under the Ohio rules, all boilers installed after Jan. 1, 1912, must be fully braced in accordance with the best engineering practice, viz: that the braces shall carry all the load; but when the new law was put into effect a large number of horizontal tubular and flue boilers were already installed that were insured by recognized insurance companies and inspected by their experts. These were considered safe for the pressures at which they were operating, and yet, under the Ohio rules, these boilers would require a number of additional braces to be fitted.

In most cases, these boilers had been operated for several years in the condition under which they were found and had shown no signs of weakness or distress in this particular, so were considered sufficiently safe by inspectors for the pressure carried. Moreover, the insurance companies had large financial interest in their safety. To avoid unnecessary hardship or injustice toward the owners of these boilers, it was decided to make some allowance for the strength of the heads, and as Nichols' rule is an accepted one, it was adopted, but with a factor of safety of 8 instead of 4, which is common.

It is generally conceded that the flat head of a boiler is safer when braced as in standard practice, yet it must be admitted that there are many boilers in this country operated by reputable concerns, and insured by the largest insurance companies, which are devoid of any bracing, and have been operated at pressures of from 80 to 100 lb.

I am a firm believer in the proper construction of boilers, but it is difficult to show an owner why his boiler, which has successfully operated for years at a certain pressure, without showing any distress, should suddenly have become unsafe and must be replaced because a new rule has been enforced in the state. This might be satisfactory to the repair man, but it would be unjust to the owner.

Most boiler explosions of late years have shown the initial rupture in some portion of the shell and not in the head, which would indicate that the old method of bracing flat heads was not altogether a failure.

In making new laws and rules pertaining to the construction and inspection of boilers, it is well to make haste slowly and to consider the fairness and justifiability of the rules as applying to plants already in existence, and which are considered by competent men as being reasonably safe. In new construction, every care should be taken to see that in all details of workmanship, design and construction, the boiler conforms to every requirement of possible safety.

JOHN NERBERG.

South Norwood, Ohio.

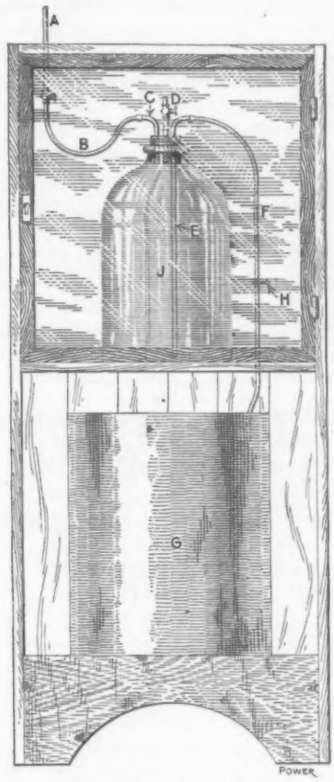
[See editorial on page 94]

Improved Flue Gas Sampler

Mr. Nelson's flue-gas sampler described in the June 4 issue is excellent, but does not possess the advantage of the one herewith described. Any engineer can make it and it is one with which cheating is impossible as the sampling bottle is locked in a case, as shown. The case consists of two sides, a top and two shelves. The upper shelf is closed in the back and has a glass door which may be locked. The lower shelf holds the waste-water can.

The sampling bottle is an ordinary 5-gal. water bottle with a cork drilled to receive three ⅛-in. brass tubes *C*, *D* and *E*. The tube *E* extends to the bottom of the bottle and acts as a siphon. The entire top of the cork should be covered with sealing wax to make it air-tight to get satisfactory results.

To take a sample, proceed as follows: Lift the can *G*, which should be full of water and of greater capacity than the bottle, to the top of the case. Now open the pinch cock *D* and allow the water in *G* to siphon through the rubber tube *F* into the bottle *J*. The rubber tube *F* is portable as it is only dropped through a hole in the upper shelf when the sampler is in operation. Allow the bottle to fill until the water flows from the cock *D*. This drives all the air from the bottle. The can *G* is now returned to the bottom shelf, the rubber tube *F* put through the hole and the sampler is ready to operate. The flue gas comes through the ⅛-in. pipe *A*, which is connected to the aspirating tube in the flue through the rubber tube *B* and the brass tube *C* into the bottle *J*. The water in *J* siphons out through the brass tube *E* and rubber tube *F* into the waste can *G*. The flow is regulated



FLUE GAS SAMPLING OUTFIT

at the cock *H*. After this is regulated satisfactorily the case is locked until it is desired to take a sample.

A. POHLMAN.

Brooklyn, N. Y.

B. S. Nelson's gas-sampling apparatus, described in the June 4 issue, is simple and; while answering some purposes, it is not as accurate as the one herewith described.

If it be only desired to determine the amount of CO_2 in the flue gases, Mr. Nelson's method will work admirably; but if, as in many cases, it is desired to make a full analysis, his method is not accurate. In a complete analysis, hydrogen and hydrocarbons are determined; gas collected over water will show an appreciably greater percentage of moisture

and hydrogen than is present, and thus give an erroneous idea of the efficiency of the furnace.

Let *A*, Fig. 1, represent a sampling

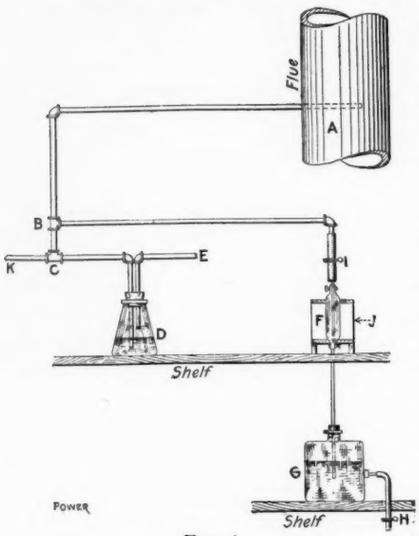


FIG. 1
FLUE GAS SAMPLING OUTFIT READY FOR OPERATION

tube placed in the flue. This should be of ¼-in. pipe extending nearly across the flue, open at the end, and with a number

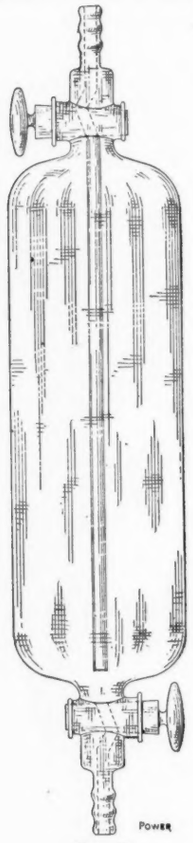


FIG. 2
SAMPLING BOTTLE

of holes drilled in it in a plane at right angles to the flow of the gases. *B* is a tee connected to the sample bottle *F* and to a steam line *K* through another tee *C*. The flask *D* is filled with water, to indicate the aspirating effect in the flue. After the steam has passed through *D* it exhausts at *E*.

The sample bottle *F*, constructed as shown in Fig. 2, is filled with mercury, which is displaced by the gas and collected in the bottle *G*. A fresh sample bottle may be filled with mercury from *G* through a rubber tube fitted with a pinch-cock *H*. The wooden stand *J* supports the sampling bottle.

The action of the apparatus is as follows: Steam passing through *K* causes an aspirating effect in the sample tube *A*, thus drawing gas from the flue. Some of this passes from *B* to the sample bottle *F*, while some is drawn down through the aspirator *D* and forced out at *E*. The sample being collected over the mercury is a true one and shows no greater percentage of moisture or hydrogen than is actually present.

A pinch-cock *L* should also be applied on the rubber tube connecting the sampling line with the bottle *F*. Sample bottles similar to the one shown in Fig. 2 may be obtained from any dealer in chemical apparatus.

CHARLES M. REED.

Annapolis, Md.

Calculating Horsepower on the Slide Rule

I read with interest the rules given by G. W. Richardson and F. R. Low for calculating horsepower on the slide rule and beg to be allowed to criticize them and offer something better.

In the first place the rules as given by Mr. Richardson are much too long to be remembered. Secondly, he uses a special mark on his slide rule which is bad, for if a mark were to be made on the slide rule for every constant one uses it would be covered with marks and the regular graduation lines be hard to read. The rule given by Mr. Low is better, but the constant used is hard to remember because it is an abstract number with no meaning attached. In addition it leaves the decimal point to be estimated, which is all right as long as familiar sizes are dealt with but not when one calculates an example that deals with sizes so small or so large that the result cannot be guessed at.

The best way of solving this particular problem is to *Multiply the m.e.p. by the piston speed and divide by* 100. *This gives the horsepower for a* 20½*-in. cylinder.*

It is then easy to find the horsepower for any other cylinder by merely changing this result in the ratio of the squares of the diameters. Thus for a 10¼-in. cylinder divide by 4, for a 41-in. cylinder multiply by 4. This can be expressed by the proportion

$$20.5^2 : \frac{Pp}{100} :: d^2 : hp.$$

which would be set on the rule as follows:

$$A \text{ scale, } 20.5^2 \qquad d^2$$
$$B \text{ scale, } \frac{Pp}{100} \qquad hp.$$

where

P = Piston speed in feet per minute;
p = M.e.p. in pounds per square inch;
d = Diameter of cylinder in inches;
$hp.$ = Horsepower.

The squares of 20.5 and of d will be found on the *A* scale above those quantities themselves on the *D* scale, and one can work with the quantities themselves instead of their squares, using the line on the runner to carry them across from the *D* to the *B* scale. The setting then becomes

$$B \text{ scale, } \frac{Pp}{100} \qquad hp.$$
$$D \text{ scale, } 20.5 \qquad d$$

EXAMPLE: What horsepower is developed by a 12x24-in. engine running at 130 r.p.m. with a mean effective pressure of 42 lb.?

First operation: calculate the piston speed.

$$P = 130 \times 4 = 520 \textit{ ft. per min.}$$

The multiplication by 4 is because the piston travels 2 × 24 in. = 4 ft. at each revolution.

Second operation,

$$\frac{Pp}{100} = \frac{520 \times 42}{100} = 218$$

A 20.5-in. cylinder will then develop 218 hp. under the above conditions.

Third operation,

$$20.5^2 : 218 : : d^2 : hp.$$
B scale, 218; 74.8 *answer*
D scale, 20.5; 12

The 218 is to be located in the second or right-hand half of scale *B*.

In performing this operation a value is assigned to each line on scale *D*, corresponding to the line which has the value 20.5. Thus the left-hand index will be 10 and the right-hand index will be 100. The line 12 on this scale will then have the value 12. This is transferred to scale *B*, where we find the answer (748); but the 218 has fixed the value of scale *B* to be 10 — 100 — 1000, that is to say, the left-hand index of scale *B* has the value 10; the center index has the value 100 and the right-hand index has the value 1000, and since the answer, 748, lies in the first half of scale *B* or between 10 and 100 it must be 74.8 and there is no need of pointing off 7 decimal places or counting how many times the right-hand end or the left-hand end of the slide projected.

This formula is based on the fact that the area of a 20.5 circle is 330 sq.in., which multiplied by the above constant of 100 gives 33,000, the equivalent in foot-pounds per minute of one horsepower.

F. F. NICKEL.

East Orange, N. J.

Turbine or Engine

I like your idea as to what constitutes a rotary and turbine engine in the editorial under the above, in the June 4 issue. I quote the latter part of the second paragraph of the article referring to the Spiro motor in the Feb. 6 issue in substantiation of my belief that it is a rotary engine, to wit: "When the ends of the grooves in which the action occurs pass the line of contact so that they are no longer closed by the teeth of the opposite gear, the fluid would be exhausted, as indicated at the end of the gear in Fig. 2," which is conclusive proof that this pressure is held upon moving surfaces until it finds an opening for exhaust, while in the turbine the angle of the vanes imparts a zig-zag motion to the entering steam which in no wise particularly affects the constancy of the flow after starting up.

Turbines, as I understand them, admit of using only one rotor altogether from the above fact in their working, while a rotary engine, being operated by a static pressure, requires some form of "head"* in order that the steam may gain some kind of a "toe hold" to be effective upon the surrounding surfaces. As will be seen from observing the characteristics of the different types, this head may vary in form greatly, and as I see it this extra rotor in the Spiro is only a modification of some existing types.

LLOYD V. BEETS.

Nashville, Tenn.

Breakage of Separator Glasses

Many readers seem interested in the breakage of separator gage-glasses, but no one has as yet advanced a tenable theory as to the cause.

It is my belief that changes in the temperature of the steam in the separator body due to the variation in pressure, are responsible for this trouble. If a steam-engine indicator be connected to the separator, it will show that the pressure fluctuates, sometimes as much as 12 or 15 lb. with each stroke of the engine, which induces severe temperature variation. This sudden change of temperature of the steam inside the glass, though small, occurs twice for each revolution of the engine and soon affects the molecular structure of the glass, resulting in crystallization. This is proved by the fact that when one of these glasses fails, it does not split or show a clean break, as a boiler gage-glass often does, but breaks up into minute particles which are thrown out in a veritable shower.

When the glass is set out from the separator body, the inside of the connecting pipes is covered with a thin film of water, which has a tendency to check any sudden variation in temperature in the pipe or glass by reëvaporating when the temperature falls, or adding condensation when it rises. This equalizes or counteracts the temperature changes and protects the glass.

F. P. READ.

Memphis, Tenn.

*Abutment [Ed.]

Saving the Heat Units

J. C. Hawkins in May 21 issue under the heading, "Saving the Heat Units," shows by his deductions and figures that a saving of 74 tons of coal a year is being effected. This looks good at first reading, but I do not think Mr. Hawkins is saving all that he thinks he is.

Before he changed the air supply it was taken in at 75 deg. F. and heated in the furnaces to the temperature of the flue gases, which requires an expenditure of many B.t.u. The air over the boiler, at a temperature of from 140 to 175 deg., he states he uses under the grate, thereby saving the heat required to raise the temperature from 75 to 175 deg., but for mechanical reasons he keeps the temperature down to 120 deg. Before the change, the air over the boilers was of a high temperature, and the temperature difference between it and the boilers, headers and piping was low and necessarily the rate of heat flow was low.

After the change a current of cold air is continually moving across the boilers. The temperature difference will be greater and therefore the heat will flow from the boilers, headers and piping much faster. It is therefore evident that Mr. Hawkins is not getting his hot air for nothing.

The difference between 75 and 175 deg. must be made up somewhere, so the heat is being supplied by radiation from the boiler.

H. R. BLESSING.

Philadelphia, Penn.

Efficiency of Joints in Boiler Shells

The article under this heading by H. L. Strong in the May 14 issue gives the impression that the only satisfactory longitudinal seam is a quadruple-riveted double-butt strap seam. After a complete discussion for calculating the efficiency of a single-riveted lap joint, at the bottom of the first column on page 704, the author states, "Such a joint is unsatisfactory." The riveting is weaker than the net section between the rivet holes but this does not necessarily make the joint improper. He argues that the efficiency of the joint is low, but this is no reason for condemning the joint.

In turn he condemns each joint for these same reasons and not once mentions the pressure he wishes to carry, upon which all of his calculations should be based. Then he infers that a quadruple-riveted butt-strap joint is the ideal seam. As a matter of fact this seam is seldom used, even on horizontal return tubular boilers where a seam of high efficiency is especially desired. Instead, triple-riveted butt joints are common. Their efficiency is fairly high and they are much cheaper to manufacture than the quadruple butt-strap joint.

The use of a quadruple or even a triple-riveted seam would be the height of folly in some cases; for example, on the drum of a Stirling boiler. A part of the shell plate in this boiler is cut out for the tubes and the efficiency at this section through the tube holes is only 45.5 per cent. Aside from the inherent objection to lap joints, which the author did not mention, the first seam would be perfectly satisfactory as long as the working pressure is kept below 85.8 lb.; for example, on a boiler generating low-pressure steam for heating purposes. Each successive joint is satisfactory as long as used on a boiler working below the corresponding pressure for the joint.

If the author had refrained from saying after each investigation that "The joint is unsatisfactory" and merely called attention to the fact that with more elaborate joints the efficiency is higher, the reader would not be left with the impression that no joint but the quadruple-riveted butt strap is worth anything, when in reality each of the other joints has its field of usefulness.

CARL E. WOLFSTYN.

Ann Arbor, Mich.

Mr. Wolfstyn's criticism of my article on "Efficiency of Joints in Boiler Shells" is appreciated, but I think he has overlooked the fact that the article was not intended to deal with the merits or demerits of any type of joint or boiler, but simply to demonstrate the methods of calculating the efficiency of the several types.

I am aware that all of the several types of joints have their fields of usefulness and that none of them are to be absolutely condemned. What was intended in saying that several of the joints under consideration were unsatisfactory was that the design or layout of those particular joints was unsatisfactory because there was too great a difference between the strength of the rivets and net section of plate between the rivet holes. It is commonly understood that the rivets in a unit length of joint should be as strong as the net section of plate between the rivet holes on the outer row.

If the layout of a joint of any type does not meet this condition it is unsatisfactory. The efficiency of the joint in such a case is not as high as it might be, and maximum efficiency can only be obtained by redesigning the joint and altering the pitch sufficiently to bring about a balance between the two factors mentioned. The unsatisfactory joints were not of standard design and the object in not making them so was given.

H. L. STRONG.

Portland, Maine.

Inquiries of General Interest

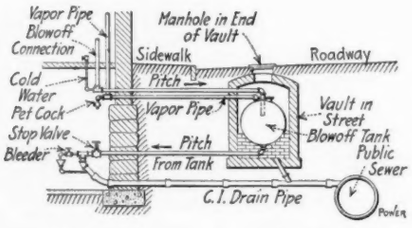
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Underground Blow-off Tank

How can a boiler blowoff tank be placed under a private street with connections for receiving blowoff water from boilers, and be provided with suitable connections for discharging into a public sewer which is 12 ft. below the surface? How large should such a tank be in proportion to size of boilers?

L. G. S.

The object being to provide means for cooling the blowoff water before it is discharged to the sewer, the tank should be large enough to hold the largest quantity of water blown off in any 24 hours, unless cooling water is used. In the latter case the tank needs to be only large enough to receive a comparatively small



UNDERGROUND BLOWOFF TANK

charge of blowoff water, to be cooled down by addition of about twice the quantity of cold water, and the mixture can be immediately discharged to the sewer. The annexed sketch explains the main features of the connections. Under any circumstances the tank should be strong enough to safely carry the full working pressure of the boilers, with liberal allowance for deterioration from corrosion.

Notched Weir

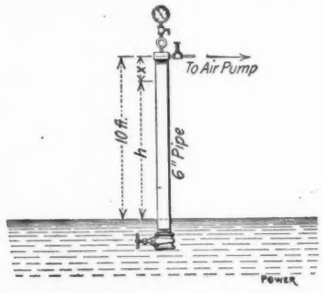
With the same head above the bottom of the weir, will the average velocity of flow per square inch of sectional area be the same over a triangular notched weir as over a rectangular weir? What is the formula for flow over a right-angled triangular weir in thin plate?

D. P. B.

The average velocity will be different. According to Prof. Thomson's experiments the flow over a symmetrical right-angle weir in thin plate is, Q in cubic feet per second $= 2.54 \times \sqrt{h^5}$, h being the depth, in feet, of the apex of the notch below the surface of still water in the pond.

Rise of Water in Vacuum Pipe

A vertical 6-in. pipe, as shown by the sketch, is provided at its lower end with a stop valve and dips below the surface of water of a pond. After closing the lower valve, water stands in the pipe at the level of the pond. The upper end of the pipe is capped and is provided with a vacuum gage and small stop valve,



RISE OF WATER IN VACUUM PIPE

which is connected to an air pump. Starting at zero on the vacuum gage, air is exhausted until the gage indicates 28 in. vacuum. If the air valve is then closed and the lower valve is opened, how high will the water rise in the pipe and how many inches of vacuum will the gage indicate?

J. W. D.

Neglecting the relatively small volume of the connections to the gage and the air valve, water would rise in the pipe a distance h until its weight, combined with the compression of air acting down on the column of water, balances the pressure of the atmosphere, i.e., 14.7 lb. per square inch absolute. Twenty-eight inches of vacuum would equal

$$(30 - 28) \times 0.491 = 0.982 \text{ lb.}$$

pressure per square inch, absolute. Assuming that temperatures remain constant and calling x the volume occupied by the air after the water is admitted, and p the absolute pressure in pounds per square inch, then the pipe being a uniform cylinder

$$p \times x = 0.982 \times 10$$

that is,

$$p = \frac{9.82}{x}$$

The pressure per square inch due to a column of water 1 ft. high being 0.433 lb. per square inch, a water column h feet high would create

$$h \times 0.433 \text{ lb.}$$

pressure per square inch at its base. Therefore,

$$\frac{9.82}{x} + 0.433h = 14.7$$

and as $h = 10 - x$, x is found to be 0.91 ft., $h = 9.09$ ft. and

$$p = \frac{9.82}{0.91} = 10.79 \text{ lb.}$$

per square inch, absolute.

Reduced to inches of mercury, this pressure would be

$$\frac{10.79}{0.491} = 21.97 \text{ in.}$$

which in inches of vacuum would be

$$30 - 21.97 = 8.03$$

Setting Valves of Duplex Pump

What is the method of setting the steam valves of a duplex pump?

W. J. C.

Remove all cylinder heads and push the piston rod of one side toward the steam cylinder until the piston would be far enough over to strike the head end of the cylinder and make a mark on the rod at the end of the stuffing-box follower. Then move the rod toward the water cylinder until the water piston would strike the cylinder head of the water end and make another mark on the rod at the end of the same follower as before. Locate a mark midway between the two marks and move the rod back until this central mark comes to the end of the same follower. The rod is then in central position.

Uncover the steam chest, move the valve to its central position and adjust the length of the valve rod so that the nut or setscrews which move the valve will be central with the lugs on the valve when the valve-rod link pin is in place. Then set the steam valve of the other side of the pump in the same manner.

Running Turbine Non-Condensing

A 250-kw. turbo-generator, at present running condensing and driving full load, is supplied with steam at 150 lb. boiler pressure from a 78-in. by 18-ft. boiler, which has 164 three-inch tubes; the grates are 6x6½ ft. and supplied with natural draft. Can sufficient steam be generated under the same boiler conditions for running the turbine noncondensing when driving the same load?

J. G. D.

Assume that a turbine of this size when running condensing uses 20 lb. of steam per kilowatt-hour, and running noncondensing would use practically twice as

much, making the steam consumption 250 × 40 = 10,000 lb. per hour, then allowing an evaporation of as much as 10 lb. of water per pound of coal, 1000 lb. of coal would have to be burned per hour on a grate of 39 sq.ft., that is, 25.6 lb. of coal per square foot of grate per hour, which could not be done with ordinary natural draft.

Study Questions

This Week's Questions
Last Week's Answers

(46) Over what yard area can a portable electric drill be used that is attached by a 35-ft. cable to one corner of a building 30 ft. long by 20 ft. wide?

(47) A steam engine, a steam turbine and a gas engine were installed at different times. The steam engine's years of service equal those of the other two combined. In 5 years more the gas engine will be half as old as the turbine and in 10 years half as old as the steam engine. How long has each been in service?

(48) What is the equivalent in units of work to the heat energy required to bring 1 gal. of water at 62 deg. F. to the boiling point?

(49) Calculate the weight of a 12-ft. length of 6-in. extra-heavy pipe, given the outside diameter 6.625 in., inside diameter 5.75 in. and weight per cubic foot 480 lb.

(50) Neglecting air resistance, how far will a body fall from rest in 10 sec., and what velocity will it acquire?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

(*Answers*)

(41) Let

a = Capacity of the tank;

b = Amount of water drawn out per hour.

Then $a + 8b$ = amount pumped in 8 hr. at 60 strokes per minute.

$$\frac{a+8b}{8\times 60\times 60}=\frac{a+8b}{28{,}800}=\textit{amount pumped per stroke} \quad (1)$$

and $a + 4b$ = amount pumped in 4 hr. at 72 strokes per minute.

$$\frac{a+4b}{4\times 60\times 72}=\frac{a+4b}{17{,}280}=\textit{amount pumped per stroke} \quad (2)$$

Equating (1) and (2)

$$\frac{a+8b}{28{,}800}=\frac{a+4b}{17{,}280}$$

$$17{,}280\,a + 138{,}240\,b = 28{,}800\,a + 115{,}200\,b$$

$$11{,}520\,a = 23{,}040\,b$$

$$a = 2b \quad (3)$$

Therefore with pumping stopped the tank would empty in 2 hr.

(42) Let

x = Number of hours pump must run at 84 strokes per minute.

Then

$$a + xb = \textit{amount of water to be pumped} \quad (4)$$

From (3) in previous answer $a = 2b$; $b = \frac{a}{2}$.

Substituting for b in (4)

$$a + \frac{xa}{2} = \textit{amount to be pumped}$$

Substituting for b in either (1) or (2) of last answer, it is found that

$$\frac{a}{5760} = \textit{amount pumped per stroke}$$

Then

$$\frac{a}{5760}\times 84\times 60=\frac{7a}{8}=\textit{amount pumped per hour at 84 strokes per minute}$$

Therefore

$$x=\frac{a+\frac{xa}{2}}{\frac{7a}{8}}$$

$$\frac{7ax}{8}=a+\frac{ax}{2}$$

$$7ax = 8a + 4ax$$

$$3ax = 8a$$

$$x=\frac{8}{3}=2\tfrac{2}{3}\ hr.$$

(43) Denote the resistance of No. 1 wire by R_1 and No. 2 by R_2. Similarly let I_1 be the current in No. 1 and I_2 that in No. 2. Since both wires are joined in multiple, the drop in potential is the same through each; let this be E. Then

$$E = I_1R_1 = I_2R_2$$

and

$$I_1=\frac{I_2R_2}{R_1}=\frac{I_2\times 7}{5}$$

But the total current is 38 amp., from which

$$I_1 + I_2 = 38$$

Substituting,

$$I_2+\frac{I_2\times 7}{5}=38$$

$$\frac{12\,I_2}{5}=38$$

$$I_2=\frac{38\times 5}{12}=15.83\ amp.$$

and

$$I_1 = 38 - 15.83 = 22.17\ amp.$$

(44) The products of the specific heats, weights and changes of temperature for the two substances, copper and water, must equal each other.

$$cw\ (t - T) = c'w'\ (T - t')$$

where

c = Specific heat of copper = 0.0951;

w = Weight of copper = 1 oz.;

t = Initial temperature of copper = 212 deg.;

T = Final temperature of copper = value to be found;

c' = Specific heat of water = 1;

w' = Weight of water = 1 lb. = 16 oz.;

t' = Initial temperature of water = 55 deg.

Then

$$0.0951\times 1(212 - T) = 1\times 16(T - 55)$$

$$0.0951\ (212 - T) = 16(T - 55)$$

$$20.1612 - 0.0951\,T = 16\,T - 880$$

$$16.0951\,T = 900.1612$$

$$T=\frac{900.1612}{16.0951}=559276.$$

Therefore the rise in temperature is 0.9276, or nearly 1 deg.

(45) The formula for the modulus of elasticity is

$$F=\frac{P\,t}{A\,e}$$

where

P = Total force in lb. = 50;

t = Length in in. = 100 × 12 = 1200 in.;

A = Cross-section in in. = ½ × 0.02 = 0.01 sq.in.;

e = Deformation or stretch in ft. = value to be found;

$$30{,}000{,}000=\frac{50\times 1200}{0.01e}$$

$$e=\frac{60{,}000}{30{,}000{,}000\times 0.01}=\tfrac{1}{5}\ in.$$

Adamat Rubber Matting

A composition rubber matting, manufactured by the Flintkote Manufacturing Co., 66 Beaver St., New York City, is known as Adamat flooring. It is composed of a felt mat base with gum surfaces, making both sides usable. It has no odor, is sanitary and has the advantage of a nonslipping surface without being corrugated. It will not harden or oxidize and can be had up to 90-ft. lengths.

Our National Chamber of Commerce

A National Chamber of Commerce has been organized at Washington, D. C., and a central office established at that city. The object is to provide a national clearing house for the development and consideration of business opinion and to secure united action upon questions affecting the commercial interests of the United States.

Members of the National Chamber of Commerce will be elected from commercial or manufacturers' associations and annual conventions will be held at representative cities. Reports will be published from time to time giving the results of the discussion of the various questions taken up before the Chamber of Commerce at the conventions.

The Shear-Klean Grate

The peculiar combined rocking and sidewise motion imparted by manipulating the lever *A*, Fig. 1, is the feature of the new grate manufactured by the Shear-Klean Grate Co., Monadnock Block, Chicago. Alternate teeth of the grate bars are long and the intermediate ones short, and the longer teeth of adjacent bars interlock when the grate is assembled.

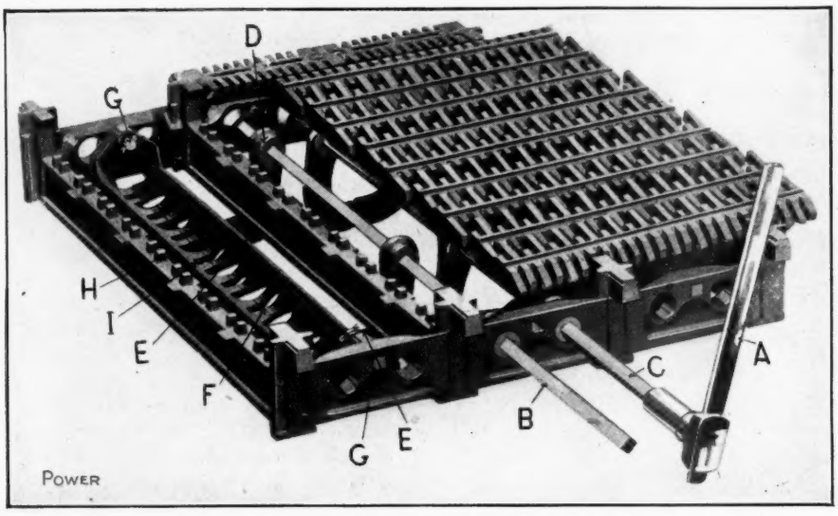


FIG. 1. PARTLY ASSEMBLED VIEW OF THE SHEAR-KLEAN GRATE

In Fig. 1 the bars on the left half of the grate have been removed to show the operating mechanism. One-half of the grate is operated by the shaft *C* and the other half by shaft *B*. When shaft *B* is rotated the levers *D* and links *E* transmit the motion to the cam operator *F*, which swings on the pins *G*. The grate bars rest on the two bearing frames between guides *H*. A long hardened steel pin *J*, Fig. 2, cored into the bottom part of each grate bar, projects through the cam slots *I*, Fig. 1, in the cam operator *F*. These slots are cut at an angle of approximately 60 deg. to the center line of the cam operator. Thus, when the cam operator is swung from side to side it has the effect of pushing the pins *J* out of the vertical position and causing the grate bars to rock back and forth.

Every second slot is longer than the intermediate ones so that the pins on the intermediate bars strike the ends of their slots when the operator has been rotated a certain amount. Further rotation of the operator causes it to push these pins sidewise and hence every other bar is shoved along sidewise in its bearings until its teeth strike the teeth of the adjacent bars. Reversing the motion of the operator causes all the grate bars to tilt in the opposite direction, the teeth of one bar scraping against those of its neighbor. Thus the teeth are self-cleaning and any slag or clinker is scraped off and falls into the ashpit.

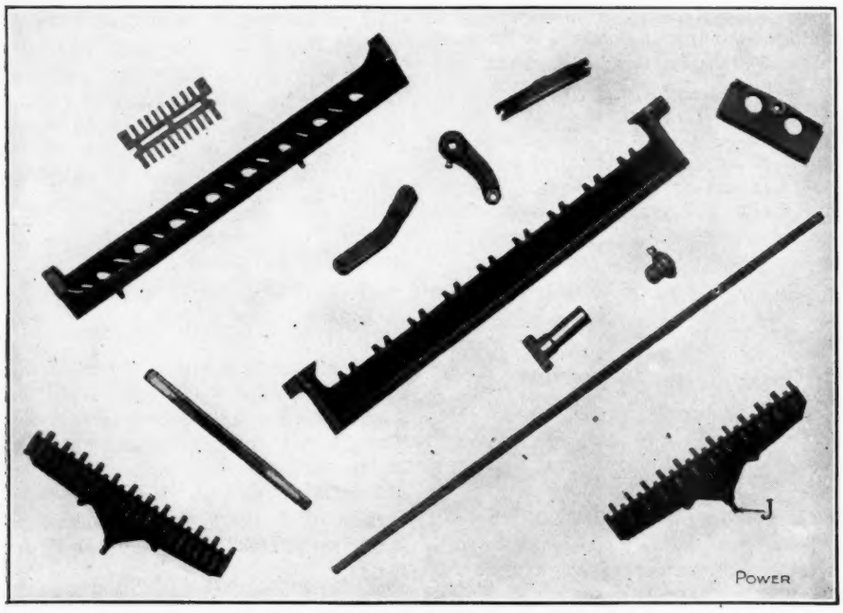


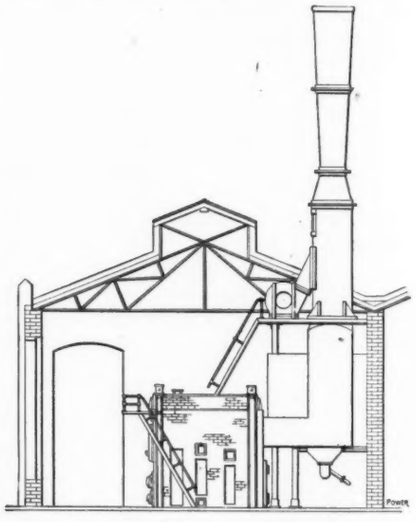
FIG. 2. THE PARTS OF THE SHEAR-KLEAN GRATE

It is claimed by the manufacturers that because of this double action of the grate the ash and clinker are cut off from the bottom of the fire in horizontal layers and no unburned coal is wasted by falling through between the bars.

Air-Jet Chimney Ventilator

In this system the draft is created by an air-jet chimney ventilator, the operating air being produced by a rotary blower which creates a suction or negative pressure in the furnace. The blower consumes but ½ of 1 per cent. (at the heaviest load of the grate 1 per cent.) of the fuel burned.

As the combustion gases do not pass through the blower expensive repairs and replacements are eliminated. This system is said to considerably increase the capacity, efficiency and advantages of the superheater and economizer, as small quantities of gases of high temperature are utilized in them. With a varying steam consumption one boiler may be forced for a time without putting extra boilers in operation, and it is possible to use low-grade fuels like lignite, brown coal, etc., in the furnace.



AIR JET CHIMNEY VENTILATOR

This ventilator is manufactured by Schutte & Koerting Co., Thompson and Twelfth Sts., Philadelphia, Penn.

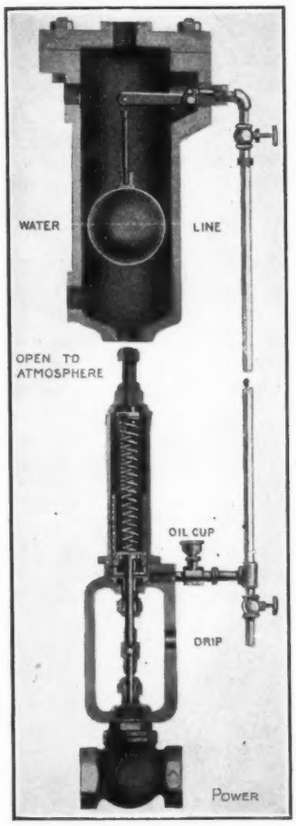
Grip-Tite Belt Dressing

This preparation is applied to belts to fill up cracks, give a velvety surface and prevent slipping. It is also said to remove moisture and lubricating oil, and to prolong the life of the belt. The dressing is applied in a liquid state. The Grip-Tite Co., New Brunswick, N. J., is the manufacturer.

Murray Boiler Feed Regulator

The Murray automatic boiler-feed regulator, illustrated herewith, is designed to automatically hold the water in the boiler at a predetermined point.

When the water in the boiler falls below its normal level, the float in the water



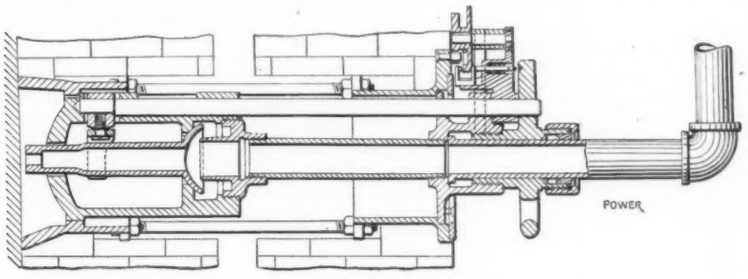
MURRAY REGULATOR

column opens the needle valve and admits steam through the ¼-in. pipe into the lower end of the cylinder, thereby forcing the piston up against the tension of the spring. This action causes the piston rod to open the regulating valve. Water is then admitted through the feed pipe into the boiler until the normal level has been restored, when the needle valve will again close as the float arises. This shuts off steam from the ¼-in. pipe and allows the spring to force the piston down, closing the regulating valve. This regulator is manufactured by the Murray Specialty Manufacturing Co., Detroit, Mich.

Improved Monarch Flue Blower

The improvement of this blower provides an automatic means for directing the steam-jet nozzles, so that the operator cannot neglect any tube in a boiler when using the machine. With the new design, it is now only necessary to turn on the steam and rotate a handwheel three or four times to clean all of the boiler tubes. The steam nozzle delivers two or more jets of steam into the tubes and registers with each tube by an automatic arrangement on the handwheel.

The device is located in the rear wall and blows the soot out in the direction of the natural draft. The movement of the nozzle is secured by means of a dog and ratchet on the handwheel, which is alternately self-engaging and self-releasing. This tube blower is manufactured by the Monarch Steam Blower Co., 187 River St., Troy, N. Y.



IMPROVED MONARCH TUBE BLOWER

Sterling Double-Oiling System Pump

The Sterling double-oiling system pump, Fig. 1, is designed to handle clean and dirty oil at the same time. The main casting contains a steel rack plunger which is reciprocated by a gear segment fastened to a shaft extending through the pump and having at its outer end a lever connected to some moving part of the engine. The operating lever has eight adjusting holes to control the amount of oil pumped, and it is also adjustable on the shaft which it drives so that it may be set at any angle. It is, therefore, possible to arrange the movement of the main pumping plugner so that it will travel from its extreme position at the end of the stroke inwardly much or little, so that the pump may just comfortably handle the amount of dirty oil which it received without sucking large quantities of air through the receiving well of the dirty-oil system.

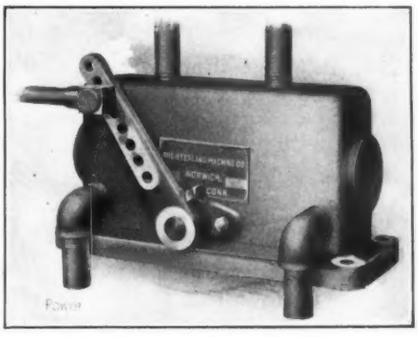


FIG. 1. STERLING DOUBLE OILING SYSTEM PUMP

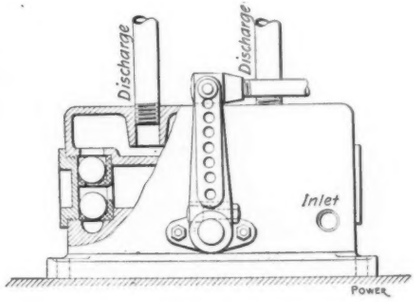


FIG. 2. VALVE ARRANGEMENT

The driving rod connecting from the engine to the pump is ⅜-in. pipe.

The pump casting has a hollow portion in the top acting as an air cushion or dome for the discharge of both ends and the steel ball valves, Fig. 2, at either end are accessible without disturbing any piping by removing their seats. The pump is manufactured by the Sterling Machine Co., Norwich, Conn.

Horsepower for Blowers

In a rule for estimating the approximate power required to displace a given amount of air at a given pressure under ordinary conditions, a certain blower manufacturer says: "Multiply the number of cubic feet delivered per minute by the pressure in ounces per square inch at the blower and the product by 0.003; divide by 11 and add 25 per cent. to the quotient."

Instead of multiplying by 0.003, then dividing by 11 and adding 25 per cent., why not multiply at once by

$$0.003 \times 1.25 \div 11 = 0.000341$$

Boiler Furnace Efficiency

On Tuesday evening, July 2, W. A. T. Willink read a paper on this subject before the Institute of Operating Engineers at its quarters, 29 West Thirty-ninth St., New York City. Its purpose was to stimulate the institute to greater action in preventing efficiency losses in boiler practice. The question, the speaker said, should not be left for solution to the consulting engineer as the operating engineer was qualified and in favorable position to make the necessary tests and correct combustion troubles.

After dwelling on the elements of combustion, Mr. Willink emphasized the im-

portance of ascertaining the volume of escaping flue gases as well as their quality. It is important because the temperature of the gases depends upon the volume. It was pointed out that "every time the air supply is doubled, the percentage of CO_2 drops from 16 to 10 per cent., and the loss in fuel will be 4 per cent., while the loss in fuel due to a drop from 10 to 4 per cent. of CO_2 is 18 per cent. Furnace conditions grow worse in geometrical ratio of progress as we go down in the scale of carbon dioxide percentages."

Mr. Willink next spoke of gas-analyzing apparatus, saying that the Orsat has the disadvantage of not being a recording apparatus. The analysis made by the Orsat is volumetric, and to get it by weight, multiply the percentages by volume by the molecular weight of the gas and divide by the sum of all products. An illustrated description of a simple and accurate recording flue-gas apparatus of German make which furnishes 40 analyses an hour, was very interesting, inasmuch as the apparatus consists chiefly of a number of intercommunicating siphons, which may be made by the engineer from pipe and pipe fittings. The suggestion was approved that blueprints be made of an apparatus patterned after the one described and distributed among the members that they might construct for themselves one devoid of troublesome complications.

After dwelling on the importance of recording the temperature and draft as well as the CO_2, Mr. Willink showed a drawing of a simple draft-recording instrument. To get the best results in combustion by draft there should be one gage to give the pressure at the bottom of the chimney where the flue enters; one to show the difference between this and the draft pressure above the grates, and a third to give the difference of pressure above and below the grate. A study of these pressures determines three prolific sources of waste in boiler practice, improper cleaning of the fires, obstructed flues and leaks in the masonry of the furnace.

Interesting discussions followed Mr. Willink's paper, in which all favored analyzing flue gases, but condemned, at least for the present, the awarding of bonuses to firemen for high percentages of CO_2. It was unanimously affirmed that bonus systems led to "jockeying" of the dampers and fires by the firemen, which, while producing high percentage of CO_2, lowered the furnace efficiency, increased the coal consumption and caused serious drops in steam pressure.

Mr. Willink responded by saying that if recording draft and temperature instruments in conjunction with the CO_2 recorder were used, this evil would cease, as those guilty would be immediately detected.

New Electric Syndicate

According to the press reports, the Westinghouse Electric & Manufacturing Co. and other interests identified with the Electric Properties Co. have, with Stone & Webster, formed a syndicate to take over the Electric Properties Co.

This last named company was formed in 1906 to acquire, finance and develop properties in which electricity is the motive force. It acquired the entire capital stock of Westinghouse, Church, Kerr & Co., and through that firm transacted a general engineering and construction business. The Electric Properties Co. had been controlled by the Westinghouse Machine Co.

Edison Co. Celebrates

As its contribution to New York City's "safe and sane Fourth," the Edison Co. furnished almost 100,000 lights, apportioned among the smaller parks. Private contractors did the wiring at the expense of the city. At City Hall alone there were 6000 lights. At Chelsea Park, where the trees are young, the enclosure only was outlined with lights. At Mount Morris Park, the southeast corner was illuminated, but the effect of a practical canopy of Japanese lanterns was striking. On Riverside Drive, thirteen consecutive trees were hung with lanterns in recognition of the original thirteen colonies.

Memphis Inspection Laws

The Board of Commissioners of the city of Memphis, Tenn., has adopted an ordinance to regulate the construction and inspection of steam boilers and generators and their appurtenances and connections, etc., which provides for internal inspection at least once a year and is to be enforced by a city boiler inspector and the police department. The rules attending to and made part of the ordinance appear to be those of the Massachusetts Board. F. H. Camble is boiler inspector.

Cannot Sell Current below Cost

Permission for the Groton, Mass., municipal light board to sell current at 10.8 cents per kilowatt-hour has been refused by the Massachusetts Gas & Electric Light Commission. The town wanted to sell current at 12 cents per kilowatt-hour for commercial lighting with a 10 per cent. discount. Croton supplies 69 private customers and its public buildings.

The commission states that as it has obviously cost the town more than 12 cents to supply current, the private customers must bear their full share of the burden which the town assumes. A supply for less than cost compels the public "to pay for the special advantages enjoyed by a few."

Explosion at Ruppert Plant

By the blowing out of a compressor head and the bursting of the big ammonia pipes in the refrigerating plant of the Jacob Ruppert brewery, New York City, on June 28, Max Taboer, the assistant engineer, was instantly killed, four other employees seriously injured and the plant slightly damaged. Forty employees whose work takes them into the plant escaped.

The plant had five large ammonia tanks and 15 miles of circulating pipe through all parts of the brewery.

The fire department had great difficulty in closing the feed pipes as the men had to travel through 125 ft. of the accumulating fumes, but in 20 min. after their arrival they succeeded in turning off six valves and returned to the open in safety.

The damage to the brewery itself was comparatively slight. Some of the piping in the power plant was loosened, but the five dynamos were uninjured and were set running a half hour after the accident. The cause of the explosion is unknown.

Cyclone Shuts Down Plant

Meager press reports from Regina, Saskatchewan, state that on June 30 a cyclone destroyed eight blocks in that city, putting the power plant out of commission. The wires are all down and the town is without light or power. Everything is being done to repair the damage. There are about 200 persons dead and injured, and it is estimated that the property loss will be nearly $2,000,000.

Canadian A. S. E. Convention

On July 23, 24 and 25, at Belleville, Ont., the twenty-third annual convention of the Canadian Association of Stationary Engineers will be held. The headquarters will be at the Hotel Quinte. Belleville Lodge No. 34, in conjunction with the national officers, has worked very hard for the success of the convention, and as the city is centrally located, it is expected that the attendance of delegates this year will be unusually large.

The local body has sent invitations to engineers, manufacturers, superintendents of plants and others interested to visit the mechanical exhibit, which will be held in connection with the convention. An elaborate program of entertainment has also been arranged.

The association has issued a handsome 100-page souvenir setting forth the many advantages of Belleville as a convention city and giving a history of the organization. It is well illustrated with portraits of the association officials and views of the many places of interest in and about Belleville.

Iowa N. A. S. E. Convention

The ninth annual convention of the Iowa State Association of the National Association of Stationary Engineers was held at Sioux City, on June 27, 28 and 29. The exhibit hall in the Auditorium was formally opened on Thursday afternoon, June 27, at 2 o'clock. At 8 p.m., G. B. Van Tassel gave an illustrated lecture on "Combustion," after which an informal smoker was attended by delegates and guests.

On Friday morning, Chairman F. E. Newkirk opened the first business session, at 9 a.m. Following the invocation, by the Rev. Smith, Mayor A. A. Smith welcomed the association, National Secretary Fred Raven responding. Harry Jones lectured on "The Indicator" and addresses were made by the officers and invited speakers and committees were appointed on credentials, ways and means, constitution and auditing.

At the afternoon session, W. A. Converse, chemical director of the Dearborn Drug & Chemical Works, gave an illustrated lecture on "Water for Boiler Use." Later, the delegates and visitors witnessed a baseball game between the engineers and supply men, at Riverside Park; the former won. In the evening a banquet was served at the pavilion.

At the Saturday morning session, the reports of the officers and committees were received. The constitution committee recommended changing the section relating to the calling of the annual state convention to read: "The convention shall be convened at the discretion of the state officers, the date to be announced in January of each year." The recommendation was ratified.

The special license-law committee recommended that the new committee be instructed to draft a license law and submit it to the national license-law committee for approval and support. This law, after approval by the national committee, is to be submitted to the state legislature.

C. W. Naylor, of Chicago, gave a lecture on "Station Costs and Operation," followed by brief talks by National-Secretary Raven, F. E. Ransley, president Central States Exhibitors Association; Abner Davis, F. E. Newkirk, W. L. Osborne, R. E. Hills, W. G. Graham, H. M. Jones and F. M. Williamson.

At the afternoon session the following officers were elected: President, A. E. Powell, Burlington; vice-president, John Devine, Des Moines; secretary, Abner Davis, Cedar Rapids, reëlected; treasurer, Robert Mullen, Marshalltown; conductor, C. E. Goodwin, Burlington; doorkeeper, A. R. Mutton, Waterloo; state deputy, James A. Coulson, Burlington. Secretary Raven installed the officers. On the recommendation of A. E. Powell, Burlington was chosen for the next state convention.

The exhibit hall was unusually well adapted to exhibition purposes and the various booths of the members of the Central States Exhibitors Association, which had charge of the hall, were well arranged and fully deserved the attention which the delegates and visitors bestowed upon them. The following exhibited:

THE EXHIBITORS

American Steam Gauge & Valve Manufacturing Co., V. D. Anderson Co., Crandall Packing Co., Dearbon Drug & Chemical Works, Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills-McCanna Co., Home Rubber Co., Jenkins Brothers, H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., Osborne Valve & Joint Co., William Powell Co., POWER, Schaeffer & Budenberg Manufacturing Co., C. E. Squires Co., United States Graphite Co., Murray Iron Works Co., Anchor Packing Co., the Under-Feed Stoker Co. of America, Valvoline Oil Co., Sioux City Air Compressor Co., Western Boiler Compound Co., George B. Carpenter Co., Quaker City Rubber Co., Interstate Electric & Manufacturing Co., Commercial Lubricating Co., Western Valve Co.

SOCIETY NOTE

The German Masonic Engineers Association of New York, with a membership of 75, will apply for a charter at the coming convention of the Universal Craftsmen at St. Louis. There are about 500 German-speaking engineers connected with the fraternity in New York City.

OBITUARY

ANDREW E. STEVENS

On June 23, Andrew E. Stevens, manager of the Consumers Power Co., Minot, N. D., was so badly injured in an automobile accident that he died within three hours after reaching the hospital.

He was born in Rushford, Minn., Feb. 7, 1869, and was educated in the Winona public schools and in the University of Minnesota.

Mr. Stevens had been in the employ of H. M. Byllesby & Co. since January, 1911. He had several years' experience in shop and street-railway work in Minneapolis and St. Paul, and had managed several telephone exchanges for the Wisconsin Telephone Co. For several years prior to engaging with Byllesby & Co. he was on the sales force of the Fort Wayne Electric Works.

Mr. Stevens was a member of the Beta Theta Pi fraternity. In Minot he was an active member of the Commercial, Elks and Minot Gun clubs.

Mr. Stevens is survived by his widow, a son, mother, two brothers and a sister. The funeral was held Tuesday afternoon, June 25, from the home of Mr. Stevens' mother, 905 West Franklin Ave., Minneapolis.

PERSONAL

Charles A. Harmony, municipal electrician at Centralia, Wash., has been appointed district superintendent for the Washington-Oregon Corporation.

Frank B. Goss, who has been with the B. F. Sturtevant Co. for the past seven years, is now sales manager of the Blaisdell-Canady Co., New York City.

Howard Lancaster has resigned his position as city electrician of Paris, Ky., to become superintendent of the telephone service of the Lexington & Eastern R.R., Lexington, Ky.

C. M. Rogers, who was recently appointed combustion engineer of the Empire District Electric Co., Joplin, Mo., is just recovering from a six weeks' attack of typhoid fever.

E. L. Murphy has been appointed to succeed F. A. Buss as the Western representative of the Ohio Brass Co., Mansfield, Ohio, with offices in the Fisher Building, Chicago.

Robert R. Keith, formerly with the Sterling Machine Co., Norwich, Conn., has accepted the position of assistant superintendent with the Sheffield Car Co., Three Rivers, Mich.

Reuben Bowen, connected with the International Steam Pump Co. for several years, latterly as district and department sales manager, has resigned to accept the position of general sales manager of the Epping-Carpenter Co., Pittsburgh, Penn.

Oscar M. Frykman has been appointed city electrician of Minneapolis, Minn., succeeding F. G. Dustin, who resigned to enter the commercial field as manager of the Northern Electrical Co., Minneapolis. Mr. Frykman is an electrical man of experience and has served as first assistant in the city department during the last three years.

Charles B. Moore, formerly vice-president of the American Arch Co., of New York City, and inventor of a number of locomotive devices, has been elected a vice-president of the Jacobs-Shupert U. S. Firebox Co., of Coatesville, Penn. Mr. Moore will have charge of the Western offices of the company, in the Railway Exchange Building, Chicago, Ill.

E. J. Wehrly and George R. Lyon, respectively president and vice-president and treasurer of the newly organized Power Equipment Co., which succeeds the power-plant department of the Arbuckle-Ryan Co., Toledo, Ohio, have been associated with the latter concern for several years. All unfinished power-plant construction contracts of the Arbuckle-Ryan Co. have been turned over to the Power Equipment Co., which will continue as contracting engineers for the installation of complete power plants, and as sales agents for the Stirling water-tube boiler and the C. & G. Cooper Co. Corliss and uniflow types of steam engines. The offices of the new company are at 305-307 Nasby Building.

Moments with the Ad. Editor

It is only occasionally when we stop to think that we realize what a lot of genuine fun we can get out of our work.

Of course every one can readily see the pleasure artists of all kinds take in their pursuits —the pleasure a painter gets from his picture, the sculptor from his statue, the composer when the band crashes out the stirring music that is the fruit of his toil.

But what we are more directly concerned with right here is the pleasure the every day man can get out of his work—the farmer from tilling the soil, the business man in closing a deal, you—the engineer—in keeping your plant at top-notch efficiency.

When the philosopher said, "So much as you put into your work so much it will return you," he was not trying to put a lot of meaningless high brow stuff over on us.

Any man who has done a day's honest work knows the remarkable simplicity and the vital truth of that saying.

The better you do your work, the better you like it—the better satisfied you are with your position and with yourself.

Doing our work with interest, working heartily, cheerfully, steadfastly and giving it the best that is in us robs our toil of a great deal of the laboriousness it may contain.

There is also a very practical side to this question. Take your own profession.

If an engineer has but little interest in his plant, if he does only what is absolutely required of him and no more, if he "holds down" his job and that is about all, it's a foregone conclusion that he can't advance very rapidly nor far.

On the other hand if he be alert to seize every chance for improving his plant, for adding to its efficiency in some particular, for eliminating any error that causes waste, a certainty it is the man higher up will notice it.

The employer who sees his engineer taking pleasure in his work will be far more ready to grant increased wages than would the employer who sees his man do his work merely as a matter of duty.

Advertising has directly helped many a man to strengthen his position, to qualify himself for advancement and to increase his interest in his job.

If you see an article advertised and know that it can improve your plant, if you root for its installation, and finally see it on duty in your engine room giving the kind of service you expected, you'll get the same kind of pleasure out of the experience that any good workman, no matter what his work, from banking to shoveling, gets out of a job well done.

That is one reason why it pays to keep in constant touch with the advertising pages of "Power." Here are advertised devices and appliances designed solely for the purpose of cutting-down the cost of operating the power plant and increasing its efficiency.

These pages, rightly used, offer the engineer an opportunity to improve the plant that is in his charge, to advance in his profession and to add vastly to the pleasure he can get out of his work.

Get the habit of studying them every week and you'll soon appreciate the truth of this.